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ABSTRACT

The second of a two-book course in drafting, this manual consists of 12 topics in the following units: sketching techniques, geometric constructions, orthographic views, dimensioning procedures, basic tolerancing, auxiliary views, sectional views, inking tools and techniques, axonometrics, oblique, perspective, and computer-aided drafting. Included in the individual instructional units are some or all of the following: performance objectives, suggested activities for teachers, information sheets, assignment sheets, job sheets, visual aids, tests, and test answers. Instructional materials in the publication are written in terms of student performance using measurable objectives and include the content necessary for employment in an entry-level drafting occupation. (MN)

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BASIC DRAFTING: BOOK TWO

by

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Developed by the

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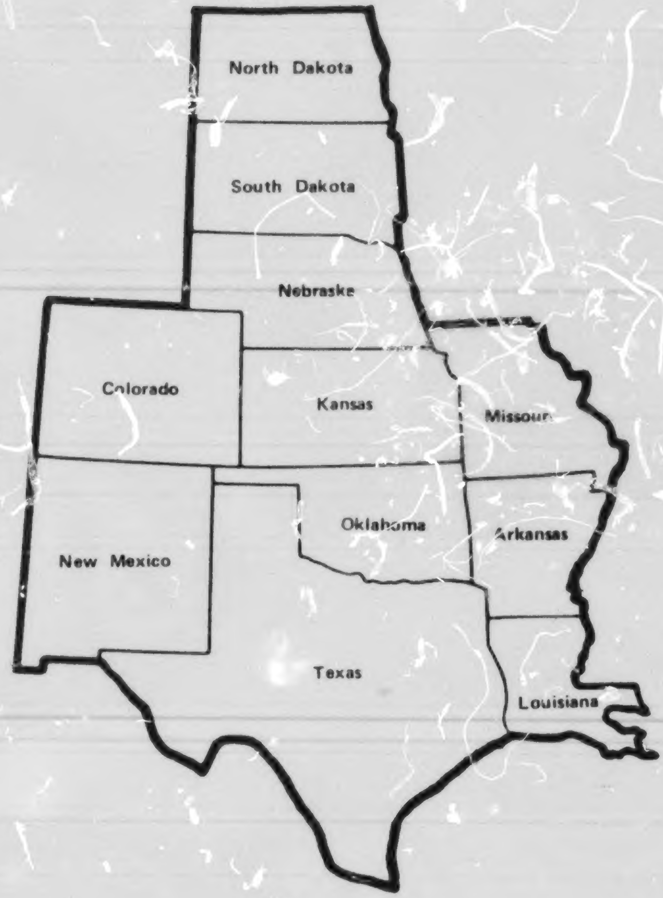
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FOREWORD

Basic Drafting: Book Two is the second volume of a series of drafting materials being produced by the Mid-America Vocational Curriculum Consortium. This book and *Basic Drafting: Book One* comprise the basics necessary to be employed in a drafting occupation. Areas of specialization such as Mechanical Drafting and Architectural Drafting are being written as supplements to be used with this book.

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its development. The technical writers have numerous years of industry as well as teaching and writing experience. Assisting them in their efforts were committee representatives who brought with them technical expertise and experience related to the classroom and to the trade. To assure that the materials would parallel the industry environment and to be accepted as a transportable basic teaching tool, other organizations and industry representatives were involved in the developmental phases of the manual. Appreciation is extended to them for their valuable contributions to the manual.

This publication is designed to assist teachers in improving instruction. As this publication is used, it is hoped that the student performance will improve and that students will be better able to assume a role in their chosen occupation. Every effort has been made to make this publication basic, readable, and by all means usable. Three vital parts of instruction have been intentionally omitted: motivation, personalization, and localization. These areas are left to the individual instructors who should capitalize on them. Only then will this publication really become a vital part of the teaching-learning process.

Instructional materials in this publication are written in terms of student performance using measurable objectives. This is an innovative approach to teaching that accents and augments the teaching/learning process. Criterion referenced evaluation instruments are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is the sincere belief of the MAVCC personnel and all those members who served on the committee that this publication will allow the students to become better prepared and more effective members of the work force. If there is anything that we can do to help this publication become more useful to you, please let us know.

Merle Rudebusch, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

Basic Drafting: Book Two is the second of two publications designed to include the content necessary for employment in an entry level drafting occupation. Originally intended as only one volume, the separation of *Basic Drafting* into two books was done in order to reduce the size of the materials. The result is two books that are shorter, more handy to carry, and much more convenient to work with.

In a time when educational costs continue to rise, a lower priced text will be welcomed by teachers and students alike. But more than that, curriculum materials presented in such a comprehensive size will be easier to adapt to specialty programs with industry and adult education.

There has never been a MAVCC publication in which we failed to request that teachers and educators let us know how the curriculum is working out in the classroom. Teacher response to date has helped make the MAVCC format the most solid in vocational-technical education, and this new, comprehensive publication of *Basic Drafting* should prove once more that as MAVCC continues to publish, we also continue to listen--and respond.

Ann Benson
Executive Director
Mid-America Vocational Curriculum
Consortium

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The contents of this publication were planned and review by:

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USE OF THIS PUBLICATION

Instructional Units

Basic Drafting: Book Two includes twelve units. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

Name	Identify	Describe
Label	Select	Define
List in writing	Mark	Discuss in writing
List orally	Point out	Discuss orally
Letter	Pick out	Interpret
Record	Choose	Tell how
Repeat	Locate	Tell what
Give	Label	Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate
Differentiate

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Additional Terms Used
Evaluate
Complete
Analyze
Calculate
Estimate
Plan
Observe
Compare
Determine
Perform

Prepare
Make
Read
Tell
Teach
Converse
Lead
State
Write

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

BASIC DRAFTING: BOOK TWO

INSTRUCTIONAL/TASK ANALYSIS

UNIT I: SKETCHING TECHNIQUES

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms
	2. Purposes of sketching
	3. Rules in sketching
	4. Types of sketch views
	5. Proportioning a sketch
	6. Meaning of lines
7. Sketch straight lines	
8. Sketch arcs	
9. Sketch circles	
10. Sketch an object using arcs and circles	
11. Sketch an ellipse	

UNIT II: GEOMETRIC CONSTRUCTIONS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms
	2. Types of angles
	3. Circular shapes
	4. Polygons and diagonals
	5. Basic geometric shapes
	6. Interpreting degrees in a circle
7. Bisect a line and an arc	
8. Bisect an angle	

JOB TRAINING: What the Worker Should Be Able to Do

RELATED INFORMATION: What the Worker Should Know

9. Draw parallel lines
10. Construct a perpendicular line to a line from a point
11. Divide a line into equal parts
12. Draw a line perpendicular through a point on a line
13. Draw an arc tangent to a straight line and an arc
14. Draw an arc tangent to two arcs
15. Construct a triangle with sides given
16. Construct a right triangle
17. Construct an equilateral triangle with one side given
18. Inscribe a hexagon inside a circle
19. Construct a hexagon with the distance across the flat sides given
20. Construct a circle through three given points
21. Construct a pentagon by inscribing
22. Draw an arc tangent to an acute angle and an obtuse angle
23. Draw an arc tangent to a right angle
24. Draw an involute of a circle
25. Draw an ellipse using the approximate ellipse with compass method
26. Draw a parabola
27. Join two points with a parabolic curve

UNIT III: ORTHOGRAPHIC VIEWS

1. Terms
2. Types of projection systems
3. Projection symbols

JOB TRAINING: What the Worker Should Be Able to Do	RELATED INFORMATION: What the Worker Should Know
	4. Views in orthographic projection
	5. Types of planes
	6. Line precedence
7. Identify types of planes in orthographic views	
8. Identify projection lines in orthographic views	
9. Construct a top view	
10. Construct a front view	
11. Construct a right side view	
12. Construct missing hidden lines	
13. Construct missing visible and hidden lines	
14. Construct circles and arcs using a template	
15. Make a two-view sketch	
16. Make a three-view sketch	
17. Construct a one-view drawing	
18. Construct a two-view drawing	
19. Construct a three-view drawing	
20. Construct a runout	
21. Construct a point in an orthographic view	
22. Construct a line in an orthographic view	
23. Construct a plane in an orthographic view	

UNIT IV: DIMENSIONING PROCEDURES

	1. Terms
	2. Size and shape descriptions
	3. Types of dimensions
	4. Types of lines

JOB TRAINING: What the Worker Should Be Able to Do	RELATED INFORMATION: What the Worker Should Know
	5. Rules for lines
	6. Dual dimensioning
	7. Placement of dimensions
	8. Finish marks
	9. Notes
	10. Superfluous dimensions
	11. Standard machine manufactured features
12. Construct arrowheads	
13. Dimension arcs	
14. Dimension angles	
15. Dimension curves	
16. Dimension rounded end shapes	
17. Dimension spherical objects	
18. Dimension cylindrical objects	
19. Dimension cones, pyramids, and prisms	
20. Dimension features on a circular center line	
21. Dimension a theoretical point of intersection	
22. Dimension an object using a rectangular coordinate system	
23. Dimension an object using a polar coordinate system	
24. Dimension an object using a tabular coordinate system	
25. Dimension an object using an ordinate dimensioning system	
26. Dimension an object using proper dimensioning rules and correct techniques to completely describe the object	

JOB TRAINING: What the Worker Should Be Able to Do

RELATED INFORMATION: What the Worker Should Know

UNIT V: BASIC TOLERANCING

1. Terms
2. Type of fits
3. Limit dimensions
4. Types of dimensioning systems
5. interpret decimal tolerance dimensions
6. Calculate and dimension clearance fit tolerances of mating parts
7. Calculate and dimension interference fit tolerances of mating parts
8. Calculate and assign tolerances to mating parts using standard fit tables
9. Construct a drawing using datum dimensioning

UNIT VI: AUXILIARY VIEWS

1. Terms
2. Views
3. Projection of measurements
4. Locations of reference line
5. Label points and planes of a three view object
6. Construct a primary auxiliary of an inclined plane
7. Construct a true size auxiliary of a curved surface
8. Construct true length of an oblique line
9. Determine the true angle and slope of a line
10. Determine the true angle between two planes
11. Determine visibility of crossing skew lines in space

JOB TRAINING: What the Worker Should Be Able to Do

RELATED INFORMATION: What the Worker Should Know

12. Determine the visibility of a line and a plane that cross in space
13. Locate piercing point of a line and a plane
14. Construct a secondary auxiliary view of an object
15. Construct point view of a line
16. Determine true angle between two planes in a secondary auxiliary
17. Construct a true size auxiliary of an oblique plane
18. Determine shortest distance between a point and a line
19. Determine shortest distance between two skew lines

UNIT VII: SECTIONAL VIEWS

1. Terms
2. Types of sectional views
3. Material symbols
4. Rules in sectioning
5. Conventional breaks

6. Construct various material symbols in section
7. Construct a full section of an object
8. Construct a half section of an object
9. Construct an offset section of an object
10. Construct a broken-out section of an object
11. Construct a removed section of an object
12. Construct a revolved section of an object
13. Construct a rib section of an object
14. Construct an aligned section of an object with holes, ribs, or spokes
15. Construct adjacent parts in asssembly section

JOB TRAINING: What the Worker Should Be Able to Do	RELATED INFORMATION: What the Worker Should Know
16. Construct conventional breaks	
17. Construct an assembly section	
UNIT VIII: INKING TOOLS AND TECHNIQUES	
	1. Terms
	2. Types of drawing inks
	3. Use and care of technical pens
	4. Precautions when using ink
	5. Tips for working with ink
	6. Alphabet of ink lines
7. Draw and erase ink lines on vellum or tracing cloth	
8. Draw and erase ink lines on polyester film	
9. Complete steps in inking a drawing or a tracing	
10. Fill clean technical and pocket model pens	
11. Refill a technical pen	
12. Clean technical and pocket model pens using the standard cleaning method	
13. Clean a technical pen with an ultrasonic cleaner	
UNIT IX: AXONOMETRICS	
	1. Terms
	2. Types of axonometrics
	3. Positions
	4. Plane surfaces
	5. Rules in constructing isometrics
	6. Rules in dimensioning isometrics
7. Sketch an isometric drawing	
8. Sketch isometric circles	

JOB TRAINING: What the Worker Should Be Able to Do

RELATED INFORMATION: What the Worker Should Know

9. Construct an axonometric drawing by box method
10. Construct angles on an isometric
11. Construct isometric circles and arcs
12. Construct isometric curves by coordinates
13. Measure in isometric by offsets
14. Construct an isometric in the center of a drawing media

UNIT X: OBLIQUE

1. Terms
2. Types of oblique drawings
3. Positions
4. Rules in constructing oblique drawings
5. Rules in dimensioning oblique drawings

6. Sketch an oblique
7. Construct an oblique drawing by box method
8. Measure in oblique
9. Construct angles on an oblique object
10. Construct oblique circles
11. Construct oblique circles in depth plane
12. Construct an oblique drawing in the center of a drawing space

UNIT XI: PERSPECTIVE

1. Terms
2. Types of perspectives
3. Types of perspective views
4. Perspective equipment
5. Lines and points

JOB TRAINING: What the Worker Should Be Able to Do

RELATED INFORMATION: What the Worker Should Know

6. Sketch a one point perspective
7. Sketch a two point perspective
8. Construct a one point perspective
9. Construct a two point perspective
10. Construct curves in a perspective

UNIT XII: COMPUTER-AIDED DRAFTING

1. Terms
2. Hardware
3. BASIC symbols and words
4. Operating a Tektronix CAD system

5. Program in BASIC using a micro-computer as a calculator
6. Create drawings on a micro-computer using plot method
7. Construct a two-view drawing using straight line statements
8. Construct a two-view drawing using straight line, circle, and hidden line statements
9. Start up and shut down the available CAD system
10. Load from and store onto tape a program
11. Operate a digitizer tablet

TOOLS, MATERIALS, AND EQUIPMENT LIST

Standard triangles
Compass
Divider
Protractor
Irregular curve
Drafting machine or parallel bar
Adjustable triangle
V-track drafting machine
Elbow drafting machine
Sheet of vellum without a watermark
Nonabrasive hand eraser
Drawing pencil with soft lead
Lead holder or pencils
Lead pointer
Drawing paper or media
Pencil pointer
Paper towel or cleaning cloth
Braddock Rowe triangle
Drawing surface or table
Ames type lettering guide
Drafting tape
Horizontal machine scale
Vertical machine scale
Scale wrench
Hex wrench
Architect scale
Metric scale
Technical pen
Ink
Standard fit tables
Lead
Triangles 45°, 30° 60°
Cleaning solution
Lint-free cloth or tissue
Ultrasonic cleaner
Ultrasonic cleaning fluid

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W. Van Hoy, Andy. *Interactive Graphic Systems Software Program*. Mimeographed. Lawton, OK, 1980.

X. Wright, Lawrence Sidney. *Drafting Technical Communication*. Bloomington, IL: McKnight and McKnight Publishing Co., 1968.

ADDITIONAL MATERIALS

A. Filmstrip/cassette--"Drafting-Series I and II." Doubleday Multimedia; 1371 Reynolds Avenue; Santa Ana, CA 92705

B. Filmstrip/cassette--"Drafting/Mechanical Drawing." Prentice Hall Media; Serv Code VD354; 150 White Plaines Road; Tarrytown, NY 10591.

C. Transparencies--"The ABC's of Drafting." DCA Educational Products: DCA Incorporated, Warrington, PA 18976.

SKETCHING TECHNIQUES
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purpose and procedures for various types of sketching. The student should also be able to sketch straight lines, arcs, circles, and ellipses. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to sketching techniques with their correct definitions.
2. State purposes of sketching.
3. Select true statements concerning rules in sketching.
4. Arrange in order the steps in completing a drawing.
5. List two types of sketch views.
6. Select true statements concerning guidelines for sketching straight lines.
7. Arrange in order the steps for sketching arcs.
8. Arrange in order the steps for sketching circles.
9. Match methods for sketching ellipses with their procedures.
10. Arrange in order the steps for blocking in a view.
11. Select true statements concerning factors in center line usage.
12. Define two methods for proportioning a sketch.
13. List three ways to interpret the meaning of lines.
14. Demonstrate the ability to:
    a. Sketch straight lines.
    b. Sketch arcs.
    c. Sketch circles.
    d. Sketch an object using arcs and circles.
    e. Sketch an ellipse.

SKETCHING TECHNIQUES
UNIT I

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Discuss advantages and disadvantages of sketching.

VII. Demonstrate to the class the techniques used in making a field sketch.

VIII. Practice sketching techniques.

IX. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  A. Objective sheet
  B. Information sheet
  C. Transparency masters
    1. TM 1--Straight Line Sketches
    2. TM 2--Sketching Arcs, Circles, and Ellipses
    3. TM 3--Steps in Blocking in a View
    4. TM 4--Proportion in Sketching
    5. TM 5--Meaning of Lines
  D. Assignment sheets
    1. Assignment Sheet #1--Sketch Straight Lines
    2. Assignment Sheet #2--Sketch Arcs
    3. Assignment Sheet #3--Sketch Circles
    4. Assignment Sheet #4--Sketch an Object Using Arcs and Circles
    5. Assignment Sheet #5--Sketch an Ellipse

E. Test

F. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

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C. Giesecke, Frederick E., et al. *Technical Drawing.* New York, NY 10022: Macmillan Publishing Co., Inc., 1980.

D. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

SKETCHING TECHNIQUES
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. A picture is worth a thousand words--A concept used by drafters, architects, and engineers to express an idea on paper so that it can be understood by other people involved

   B. Freehand technical sketching--Making a drawing without the use of instruments, yet with care taken to obtain the correct line widths

      (NOTE: The drawing must not be crude or sloppy.)

   C. Radius--The distance from the center point of a circle to the outside circumference

   D. Diameter--The distance across a circle passing through its center point

   E. Arc--Any portion of the circumference of a circle

   F. Ellipse--A foreshortened circle having a major axis and a minor axis

   G. Sketch lines--Freehand connections between two or more points

   H. Focus (foci)--A point(s) at which lines come toward each other or move away from each other

   I. Major axis--The axis passing through the foci of an ellipse

   J. Minor axis--The chord of an ellipse passing through the center and perpendicular to the major axis

II. Purposes of sketching

   A. Preliminary approach to a problem before going to the expense of making an instrument drawing

   B. To give the drafter a better picture of the object to be drawn

   C. For recording notes and technical information in the shop or field for future use in the drafting department

   D. As an aid to "think through" the solution to an engineering-type problem

INFORMATION SHEET

III. Rules in sketching

   A. A scale is not required

   B. Small objects are sketched larger than their normal size

   C. Freehand lines are rough, not rigid

   D. Sketches are drawn in proportion

   E. Line contrast should be used

   F. A soft pencil should be used

   G. Finished linework should be dark and conform to line alphabet standards

   H. Sketches are dimensioned the same as machine drawings

IV. Steps in completing a drawing

   A. Select necessary views

   B. Block in lightly the shape of the object

   C. Block in details in each view

   D. Erase unwanted construction lines

   E. Darken lines

V. Types of sketch views

   A. Pictorial

   B. Multiview

VI. Guidelines for sketching straight lines (Transparency 1)

   A. Properly locate end points of line

   B. By trial movement from left point to right point, position arm without marking on the paper

   C. Keep your eye on the point where the line will end and sketch short, light lines between points

   (NOTE: Do not permit your eye to follow the pencil.)

   D. Erase unneeded lines with a soft eraser and darken the remaining line to form one uniformly wide, continuous line

   (NOTE: At this stage, your eye needs to lead the pencil along the light sketch line.)

INFORMATION SHEET

E. Draw straight lines that are parallel to the drafting table edge (border lines) by aligning the paper on the drafting board edge and letting the third and fourth fingers of the drawing hand act as a guide by sliding them along the edge of the board while drawing the line

(CAUTION: This should be done only on tables with proper edging material.)

F. Rotate the paper for inclined straight lines to a position that would make them straight lines

G. Estimate angles by sketching a right angle and a 45° angle; subdivide into 15° angles, and then obtain the required angle

H. Erase all unneeded construction lines

VII. Steps for sketching arcs (Transparency 2)

A. Sketch right angle at the proper length

B. Box in to form a square and mark proper diagonal

C. Mark off proper length on diagonal

D. Darken in arc

VIII. Steps for sketching circles (Transparency 2)

A. Sketch in box to proper scale and mark midpoint of each line of square

B. Sketch in diagonals in square and mark off proper length on diagonals

C. Darken in circle

IX. Methods for sketching ellipses and procedures (Transparency 2)

A. Method 1

1. Sketch in a rectangle the length of the major axis and minor axis and mark midpoint of each line of rectangle
2. Sketch a circular arc on each line of the rectangle
3. Darken in ellipse

B. Method 2

1. Sketch in major axis and minor axis
2. Sketch a circular arc on each end of an axis line
3. Darken in ellipse

INFORMATION SHEET

X. Steps for blocking in a view (Transparency 3)

   A. Block in main shapes of object

   B. Sketch in arcs and circles

   C. Darken final lines

   D. Erase construction lines

XI. Factors in center line usage

   A. Used to show axis of symmetry

   (NOTE: Center lines are sometimes called symmetry lines.)

   B. Symbol for center line is ℄

   C. Used to show the center line of both circles and paths of motion

   D. The center line should extend past the visible line 1/4" if not being used as an extension line

   E. Long dashes should begin and terminate center lines

   (NOTE: Center lines for small holes can be a thin solid line.)

   F. A gap must be present when a center line is a continuation of a visible or hidden line

   (NOTE: Center lines need not be shown on filleted corners because they are self-locating.)

XII. Methods for proportioning a sketch (Transparency 4)

   A. Method 1--Use a piece of cardboard to mark off some unit of measurement (such as a 1/4" to form some scale); then, measure the actual object

   (NOTE: When sketching, it is important to keep the sketch in proportion.)

   B. Method 2-First, determine the overall width and height of the object; then, sketch in the medium areas (by use of diagonals if necessary); finally, sketch in the small details

   (NOTE: When the item has numerous curves, it is best to use graph paper.)

XIII. Ways to interpret the meaning of lines (Transparency 5)

   A. A visible or hidden line can mean (indicate) the intersection of two surfaces

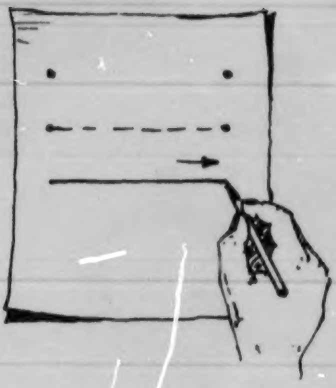
INFORMATION SHEET

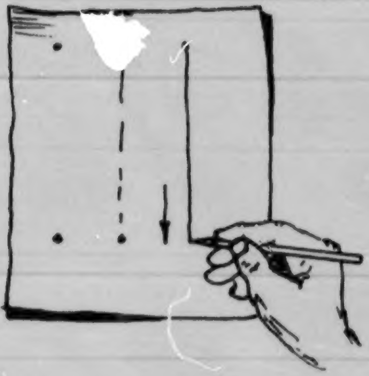
B. A visible or hidden line can mean (indicate) an edge view of a surface

C. A visible or hidden line can mean (indicate) a contour view of a curved surface

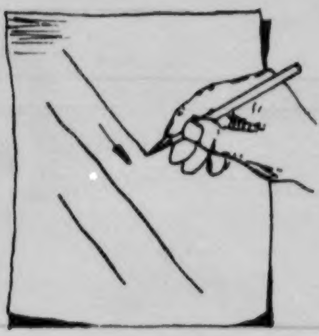
(NOTE: It is necessary to examine all views carefully to determine their meaning since no shading is used on working drawings.)

Straight Line Sketches

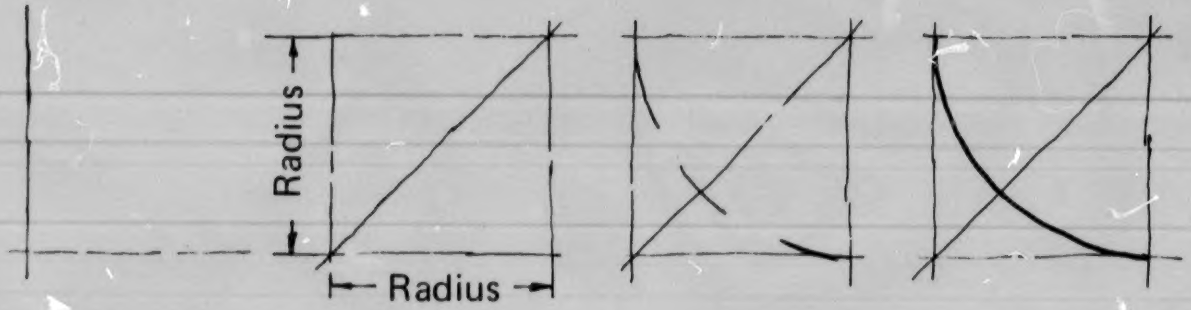


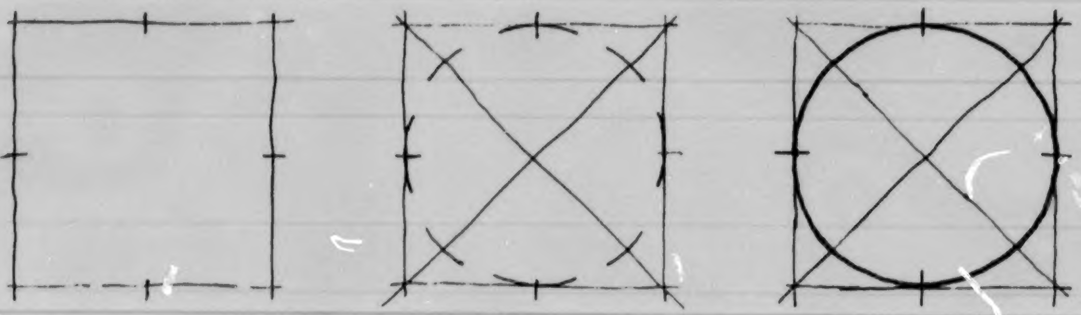


Keep eye on end point

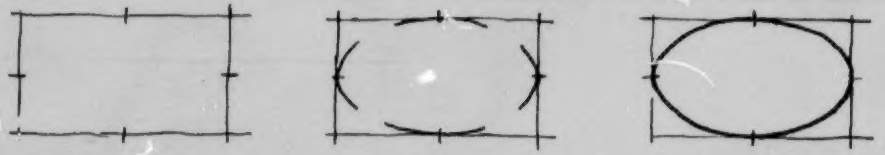


Sketching Arcs, Circles, and Ellipses

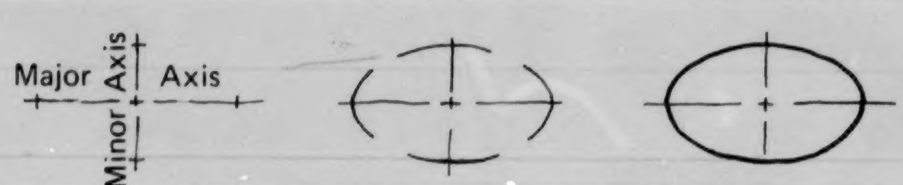

Radius
Radius



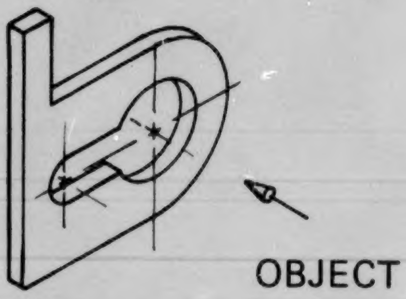
Method 1

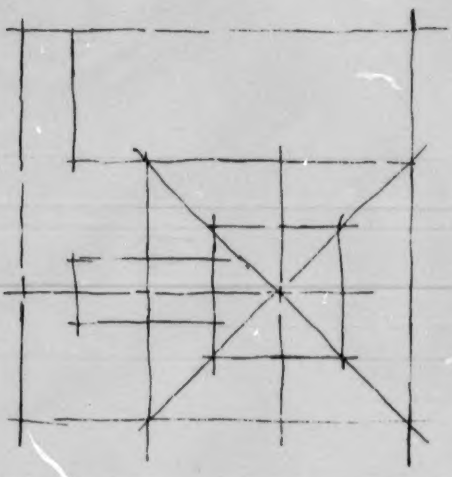


Method 2

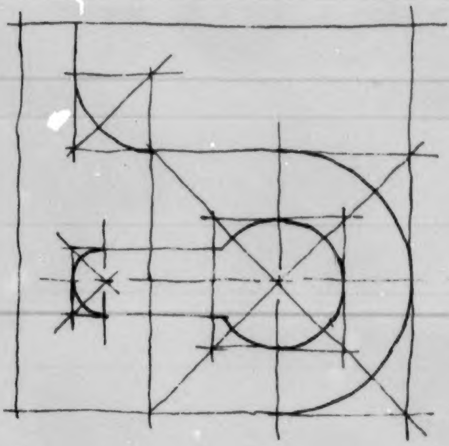

Major Axis
Minor Axis

Steps in Blocking in a View

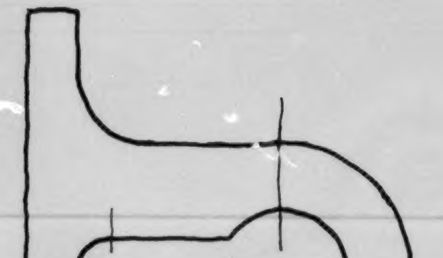




Block in Main Shapes

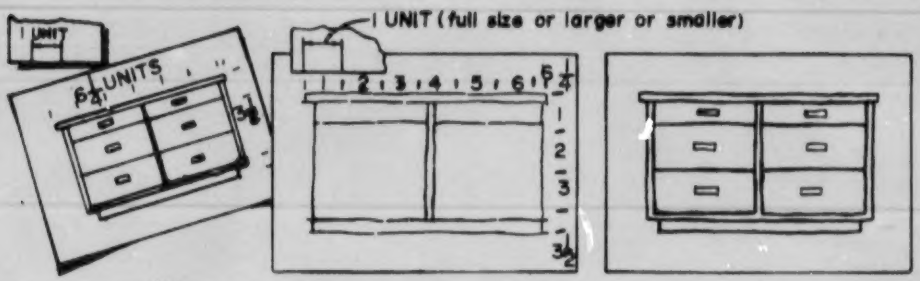


Sketch Arcs and Circles

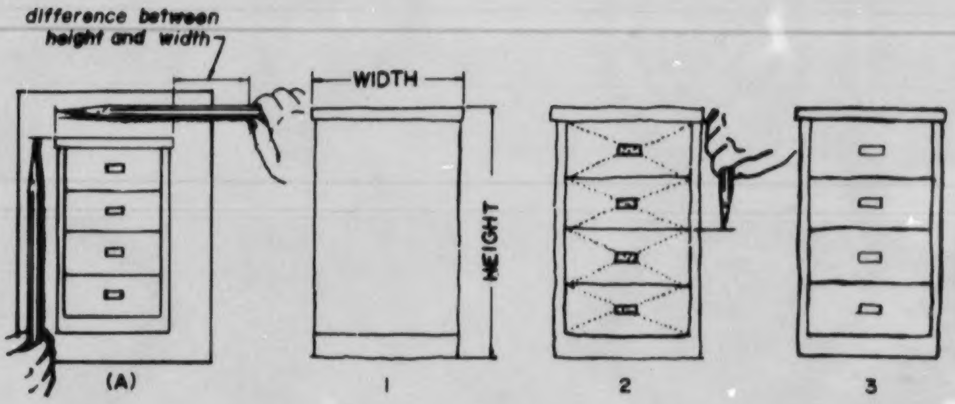


Darken Final Lines

Proportion in Sketching

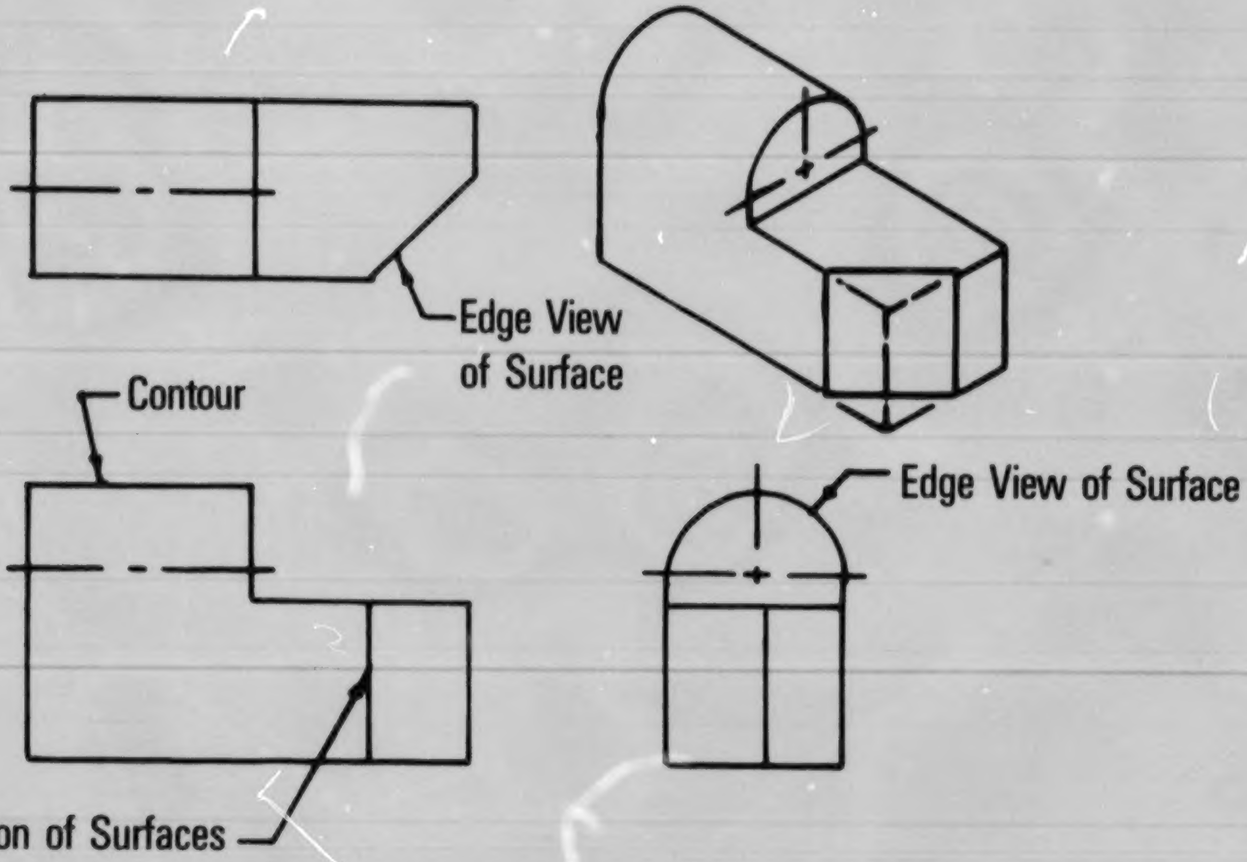

1 UNIT
5 1/2 UNITS
3 1/2
1 UNIT (full size or larger or smaller)
1 2 3 4 5 6 5 1/2
1 2 3 3 1/2

(A) 1 2


difference between height and width
WIDTH
HEIGHT

(A) 1 2 3

Meaning of Lines

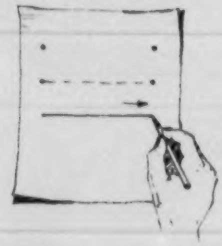

Edge View of Surface
Contour
Edge View of Surface
Intersection of Surfaces

SKETCHING TECHNIQUES
UNIT I

ASSIGNMENT SHEET #1--SKETCH STRAIGHT LINES

Premise: Straight lines can be sketched by using the procedure in the following example.

Example:



1. Draw two points
2. Draw dash lines connecting the two points
3. Darken and fill in dash lines

(NOTE: The same procedure is used for vertical and inclined lines.)

Directions: Sketch the following lines by connecting point A to point B.

Problem A: Vertical lines

A • A •

A • A •

B • B •

B • B •

Problem B: Horizontal lines

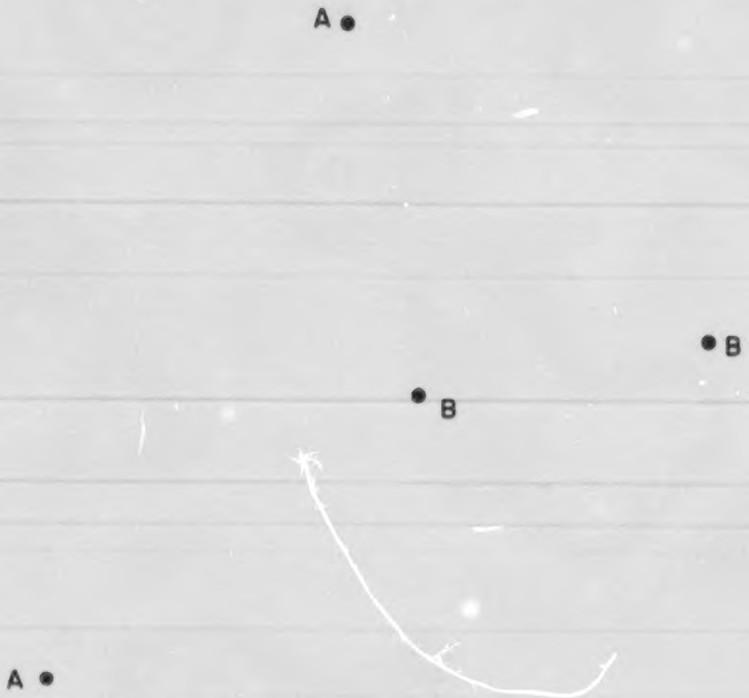
A • • B

A • • B

A • • B

ASSIGNMENT SHEET #1

Problem C: Inclined lines



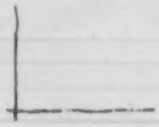
SKETCHING TECHNIQUES
UNIT I

ASSIGNMENT SHEET #2--SKETCH ARCS

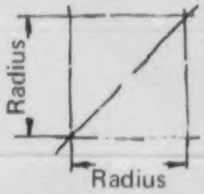
Premise: Arcs can be sketched by using the procedure in the following example.

Example:

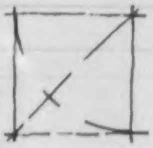
1. Sketch a box corner



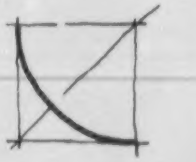
2. Mark off radius distance from corner point



3. Swing a rough arc from center point

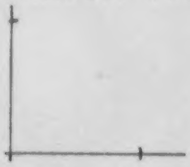


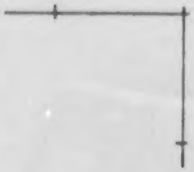
4. Darken arc

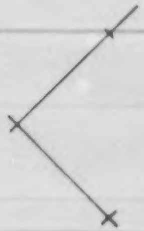


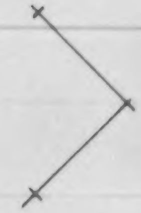
Directions: Sketch arcs in the following corners.

Problem:









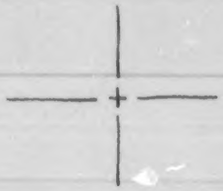
SKETCHING TECHNIQUES
UNIT I

ASSIGNMENT SHEET #3--SKETCH CIRCLES

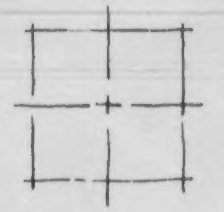
Premise: Circles can be sketched by using the procedure in the following example.

Example:

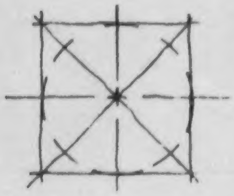
1. Sketch in center lines



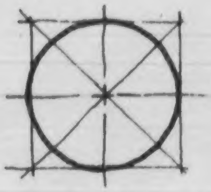
2. Box in circle at diameter required



3. Put in diagonal lines and mark radius points from center



4. Rotate wrist in a circular motion and connect circle points



Directions: Sketch three circles below using 1/2" approximate radius.

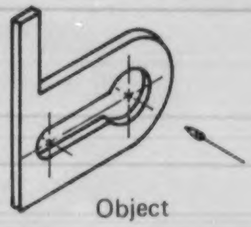
SKETCHING TECHNIQUES
UNIT I

ASSIGNMENT SHEET #4--SKETCH AN OBJECT USING ARCS AND CIRCLES

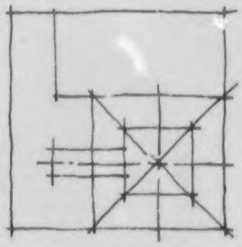
Premise: An object using arcs and circles can be sketched by using the procedure in the following example.

Example:

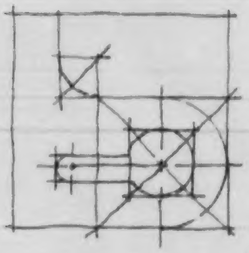
1. Decide which view of object is to be drawn



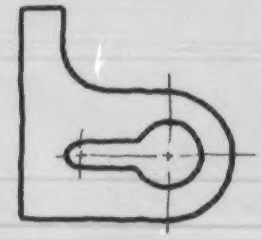
2. Box in overall shape of object



3. Sketch in arcs and circles



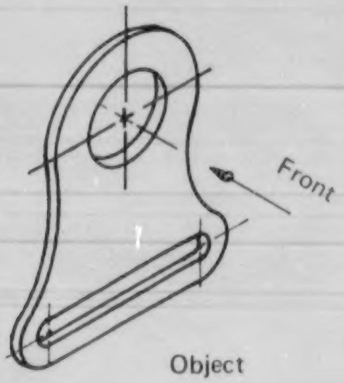
4. Erase construction lines and darken object



ASSIGNMENT SHEET #4

Directions: Sketch the front view of this object.

Problem:



Object

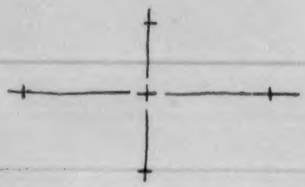
SKETCHING TECHNIQUES
UNIT I

ASSIGNMENT SHEET #5--SKETCH AN ELLIPSE

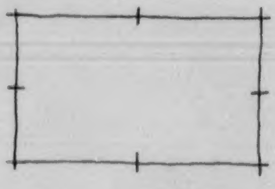
Premise: An ellipse can be sketched by using the procedure in the following example.

Example:

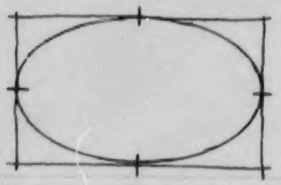
1. Mark off major and minor axes on center lines



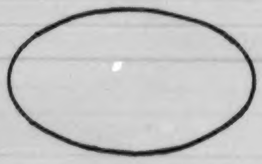
2. Box in outlines of the ellipse



3. Sketch in major and minor arcs of ellipse



4. Erase construction lines and darken ellipse outline



Directions: Sketch three ellipses using an approximate 3/4" major diameter and an approximate 1/2" minor diameter.

SKETCHING TECHNIQUES
UNIT I

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

______a. A concept used by drafters, architects, and engineers to express an idea on paper so that it can be understood by other people involved

______b. Making a drawing without the use of instruments, yet with care taken to obtain the correct line widths

______c. The distance from the center point of a circle to the outside circumference

______d. The distance across a circle passing through its center point

______e. Any portion of the circumference of a circle

______f. A foreshortened circle having a major axis and a minor axis

______g. Freehand connections between two or more points

______h. A point at which lines come toward each other or move away from each other

______i. The axis passing through the foci of an ellipse

______j. The chord of an ellipse passing through the center and perpendicular to the major axis

1. Major axis
2. Diameter
3. Arc
4. Freehand technical sketching
5. Minor axis
6. A picture is worth a thousand words
7. Sketch lines
8. Radius
9. Ellipse
10. Focus

2. State three purposes of sketching.

a. ____

b. ____

c. ____

3. Select true statements concerning rules in sketching by placing an "X" in the appropriate blanks.

______ a. An architect scale must be used in sketching

______ b. Small objects are sketched larger than their normal size

______ c. Freehand lines are finished and rigid

______ d. Sketches do not need to be drawn in proportion

______ e. Line contrast should be used

______ f. A hard pencil should be used

______ g. Finished linework should be dark and conform to line alphabet standards

______ h. Sketches are never dimensioned

4. Arrange in order the steps in completing a drawing by placing the correct sequence numbers in the appropriate blanks.

______ a. Erase unwanted construction lines

______ b. Select necessary views

______ c. Block in lightly the shape of the object

______ d. Darken lines

______ e. Block in details in each view

5. List two types of sketch views.

a. ____

b. ____

6. Select true statements concerning guidelines for sketching straight lines by placing an "X" in the appropriate blanks.

______ a. Properly locate end points of line

______ b. Position arm by marking heavily on the paper while moving from left point to right point

______ c. Keep your eye on the pencil and sketch short, heavy lines between points

______ d. Erase unneeded lines with a soft eraser and darken the remaining line to form one uniformly wide, continuous line ______e. Draw straight lines that are parallel to the drafting table edge by aligning the paper on the drafting board edge and letting the third and fourth fingers of the drawing hand act as a guide by sliding them along the edge of the board while drawing the line

______f. Do not rotate the paper to sketch inclined straight lines

______g. Estimate angles by sketching a right angle and then a 45° angle; subdivide into 15° angles, and then obtain the required angle

7. Arrange in order the steps for sketching arcs by placing the correct sequence numbers in the appropriate blanks.

______a. Mark off proper length on diagonal

______b. Sketch right angle at the proper length

______c. Darken in arc

______d. Box in to form a square and mark proper diagonal

8. Arrange in order the steps for sketching circles by placing the correct sequence numbers in the appropriate blanks.

______a. Sketch in diagonals in square and mark off proper length on diagonals

______b. Darken in circle

______c. Sketch in box to proper scale and mark midpoint of each line of square

9. Match methods for sketching ellipses on the right with their procedures.

______a. Sketch a circular arc on each end of an axis line

______b. Sketch in a rectangle the length of the major axis and minor axis and mark midpoint of each line of rectangle

______c. Sketch a circular arc on each line of the rectangle

______d. Sketch in major axis and minor axis

1. Method 1
2. Method 2

10. Arrange in order the steps for blocking in a view by placing the correct sequence numbers in the appropriate blanks.

______a. Darken final lines

______b. Block in main shapes of object

______c. Erase construction lines

______d. Sketch in arcs and circles

11. Select true statements concerning factors in center line usage by placing an "X" in the appropriate blanks.

______ a. Does not show axis of symmetry

______ b. Symbol for center line is ℄

______ c. Used to show center line of squares

______ d. Long dashes should begin and terminate center lines

______ e. A gap must be present when a center line is a continuation of a visible or hidden line

12. Define two methods for proportioning a sketch.

Method 1: ____

____

____

Method 2: ____

____

____

13. List three ways to interpret the meaning of lines.

a. ____

____

b. ____

____

c. ____

____

14. Demonstrate the ability to:

a. Sketch straight lines.

b. Sketch arcs.

c. Sketch circles.

d. Sketch an object using arcs and circles.

e. Sketch an ellipse.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SKETCHING TECHNIQUES
UNIT I

ANSWERS TO TEST

1.

a.	6	f.	9
b.	4	g.	7
c.	8	h.	10
d.	2	i.	1
e.	3	j.	5

2. Any three of the following:

   a. Preliminary approach to a problem before going to the expense of making an instrument drawing

   b. To give the drafter a better picture of the object to be drawn

   c. For recording notes and technical information in the shop or field for future use in the drafting department

   d. As an aid to "think through" the solution to an engineering-type problem

3. b, e, g,

4. a. 4
   b. 1
   c. 2
   d. 5
   e. 3

5. a. Pictorial
   b. Multiview

6. a, d, e, g

7. a. 3
   b. 1
   c. 4
   d. 2

8. a. 2
   b. 3
   c. 1

9. a. 2
   b. 1
   c. 1
   d. 2

10. a. 3
    b. 1
    c. 4
    d. 2

11. d, e

12. Method 1--Use a piece of cardboard to mark off some unit of measurement; then, measure the actual object

    Method 2--First, determine the overall width and height of the object; then, sketch in the medium areas; finally, sketch in the small details

13. a. A visible or hidden line can mean the intersection of two surfaces

    b. A visible or hidden line can mean an edge view of a surface

    c. A visible or hidden line can mean a contour view of a curved surface

14. Evaluated to the satisfaction of the instructor

GEOMETRIC CONSTRUCTIONS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match basic geometric terminology with correct definitions, match basic geometric shapes with their descriptions, and identify basic geometric shapes. The student should also be able to measure a circle and interpret the degrees in it, and construct basic geometric forms. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match basic geometric terms with their correct definitions.
2. Match types of angles with their correct descriptions.
3. Match types of triangles with their correct descriptions.
4. Match circular shapes with their correct descriptions.
5. Match four-sided shapes, cones, and special figures with their correct descriptions.
6. Match polygons and diagonals with their correct descriptions.
7. Identify basic geometric shapes.
8. Match geometric terms with their correct symbols.
9. List three elements needed for measuring parts of a circle.
10. List three elements needed for interpreting degrees in a circle.
11. Demonstrate the ability to:
    a. Bisect a line and an arc.
    b. Bisect an angle.
    c. Draw parallel lines.
    d. Construct a perpendicular line to a line from a point.

e. Divide a line into equal parts.

f. Draw a line perpendicular through a point on a line.

g. Draw an arc tangent to a straight line and an arc.

h. Draw an arc tangent to two arcs.

i. Construct a triangle with sides given.

j. Construct a right triangle.

k. Construct an equilateral triangle with one side given.

l. Inscribe a hexagon inside a circle.

m. Construct a hexagon with the distance across the flat sides given.

n. Construct a circle through three given points.

o. Construct a pentagon by inscribing.

p. Draw an arc tangent to an acute angle and an obtuse angle.

q. Draw an arc tangent to a right angle.

r. Draw an involute of a circle.

s. Draw an ellipse using the approximate ellipse with compass method.

t. Draw a parabola.

u. Join two points with a parabolic curve.

GEOMETRIC CONSTRUCTIONS
UNIT II

SUGGESTED ACTIVITIES

I. Provide students with objective sheet.

II. Provide students with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Have students make models of some geometric shapes.

VII. Since this unit is very long, items 1-10 can be given as one test and item 11 as a separate test.

VIII. Select title block you want to be used in Assignment Sheet #8.

IX. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheets
- C. Transparency masters
  - 1. TM 1--Basic Geometric Shapes and Terms
  - 2. TM 2--Basic Geometric Shapes and Terms (Continued)
  - 3. TM 3--Types of Angles
  - 4. TM 4--Types of Triangles
  - 5. TM 5--Circular Shapes
  - 6. TM 6--Circular Shapes (Continued)
  - 7. TM 7--Circular Shapes (Continued)
  - 8. TM 8--Four-sided Shapes, Cones, and Special Figures

9. TM 9--Special Figures
10. TM 10--Quadrilaterals
11. TM 11--Solids
12. TM 12--Involutes
13. TM 13--Involute of a Circle
14. TM 14--Polygons and Diagonals
15. TM 15--Polygons

D. Assignment sheets

1. Assignment Sheet #1--Bisect a Line and an Arc
2. Assignment Sheet #2--Bisect an Angle
3. Assignment Sheet #3--Draw Parallel Lines
4. Assignment Sheet #4--Construct a Perpendicular Line to a Line From a Point
5. Assignment Sheet #5--Divide a Line Into Equal Parts
6. Assignment Sheet #6--Draw a Line Perpendicular Through a Point on a Line
7. Assignment Sheet #7--Draw an Arc Tangent to a Straight Line and an Arc
8. Assignment Sheet #8--Draw an Arc Tangent to Two Arcs
9. Assignment Sheet #9--Construct a Triangle with Sides Given
10. Assignment Sheet #10--Construct a Right Triangle
11. Assignment Sheet #11--Construct an Equilateral Triangle with One Side Given
12. Assignment Sheet #12--Inscribe a Hexagon Inside a Circle
13. Assignment Sheet #13--Construct a Hexagon With the Distance Across the Flat Sides Given
14. Assignment Sheet #14--Construct a Circle Through Three Given Points
15. Assignment Sheet #15--Construct a Pentagon by Inscribing
16. Assignment Sheet #16--Draw an Arc Tangent to an Acute Angle and an Obtuse Angle
17. Assignment Sheet #17--Draw an Arc Tangent to a Right Angle
18. Assignment Sheet #18--Draw an Involute of a Circle

19. Assignment Sheet #19--Draw an Ellipse Using the Approximate Ellipse with Compass Method

20. Assignment Sheet #20--Draw a Parabola

21. Assignment Sheet #21--Join Two Points with a Parabolic Curve

E. Test

F. Answers to test

II. References:

A. Berg, Edward. *Mechanical Drawing*. Milwaukee, WI: Bruce Publishing Co., 1962.

B. Spencer, Henry C. and John T. Dygdon. *Basic Technical Drawing*. New York: Macmillan Co., 1968.

C. French, Thomas E. and Carl L. Svensen. *Mechanical Drawing*. Dallas: McGraw-Hill Book Co., 1966.

D. Wright, Lawrence Sidney. *Drafting Technical Communication*. Bloomington, IL: McKnight and McKnight Publishing Co., 1968.

E. French, Thomas E. and Charles J. Vierck. *Engineering Drawing*. St. Louis: McGraw-Hill Book Co., 1966.

G. Giesecke, Frederick E., et. al. *Technical Drawing*. New York: Macmillan Co., 1974.

H. Spencer, Henry Cecil and Ivan Leroy Hill. *Technical Drawing Problems*. New York: Macmillan Co., 1974.

GEOMETRIC CONSTRUCTIONS
UNIT II

INFORMATION SHEET

I. Basic geometric terms and definitions

A. Point–A small dot or small cross on a drawing or in space that does not have length, height, depth, or width (Transparency 1)

B. Line--A connection between two or more points (Transparency 1)

C. Straight line--The shortest distance between two points (Transparency 1)

D. Curved line--A line in which no segment is straight (Transparency 1)

E. Line segment--Any part of a line (Transparency 1)

F. Plane figure--A flat, level, even surface such as a piece of paper lying flat on a table (Transparency 1)

(NOTE: This is sometimes referred to simply as a plane.)

G. Intersect--To cut across each other (Transparency 1)

H. Vertex--The common point where lines or surfaces intersect (Transparency 1)

I. Perpendicular--At 90° angles to a given plane or line (Transparency 1)

J. Parallel--Straight lines that do not meet or intersect and are an equal distance apart at all points (Transparency 1)

K. Projection line--Line used to extend from one view to another view (Transparency 1)

L. Skew (oblique) lines–Straight lines that do not intersect and are not parallel or in the same plane (Transparency 2)

M. Bisect--To divide into two equal parts (Transparency 2)

N. Vertical--A line straight up and down perpendicular to the horizontal plane (Transparency 2)

O. Horizontal--Parallel to the plane of the horizon (Transparency 2)

P. Edge--What appears as a line when a plane surface is perpendicular to a plane of projection (Transparency 2)

Q. Equilateral--All sides are equal

INFORMATION SHEET

II. Types of angles and descriptions (Transparency 3)

   A. Angle–Figure formed by two intersecting lines

   B. Right angle--A 90° angle

   C. Acute angle--An angle less than 90°

   D. Obtuse angle--An angle greater than 90°

   E. Complementary angles--Two angles whose sum is 90°

   F. Supplementary angles--Two angles whose sum is 180°

III. Types of triangles and descriptions (Transparency 4)

   A. Triangle--A plane figure bound by three straight sides, and three interior angles which equal 180°

   B. Equilateral triangle--A triangle with three equal sides and three equal angles

   C. Isosceles triangle--A triangle with two equal sides and two equal angles

   D. Scalene triangle--A triangle with no angles or sides equal

   E. Right triangle--A triangle with one 90° angle

   (NOTE: The side opposite the 90° angle of a right triangle is the hypotenuse.)

IV. Circular shapes and descriptions

   A. Circumference--The distance around a circle (Transparency 5)

   B. Radius--The distance from the center point of a circle to the outside circumference (Transparency 5)

   C. Diameter--The distance across a circle passing through its center point (Transparency 5)

   D. Circle–A closed curve all points of which are an equal distance from the center (Transparency 5)

   E. Arc--Any portion of the circumference of a circle (Transparency 5)

   F. Sphere--A round body such as a ball which has all points of its circumference an equal distance from its center (Transparency 5)

   G. Concentric circles--Having the same point as center (Transparency 5)

   H. Eccentric circles--Having different points as center, one within the other (Transparency 5)

   I. Symmetrical--The same on both sides of a center line (Transparency 6)

INFORMATION SHEET

J. Inscribed --A figure drawn within another figure so as to touch in as many places as possible (Transparency 6)

K. Circumscribed--A figure encircled so as to touch in as many places as possible (Transparency 6)

L. Axis--A straight line passing through the center of a geometric body upon which the geometric body rotates (Transparency 6)

M. Torus--A solid figure generated by a circle which is revolving on an axis which is eccentrical to the circle (Transparency 6)

N. Ellipse--A foreshortened circle having a major diameter and a minor diameter (Transparency 6)

O. Cylinder--A solid figure obtained by taking a rectangle by its edge and rotating it around to its parallel edge, making the ends parallel, and the circles equal (Transparency 6)

P. Tangent--Meeting a curved line or surface, touching at one and only one point, but most definitely not intersecting (Transparency 7)

(NOTE: To make better tangencies, draw the circular object first, when possible; then draw the straight line from it.)

Q. Chord--Any straight line across a circle that does not pass through the center

R. Semicircle--One-half of a circle

S. Circular segment--Less than a semicircle

T. Quadrant--One-fourth of a circle

U. Sector--Less than a quadrant

V. Four-sided shapes, cones, and special figures and descriptions

A. Square--A plane figure bound by four equal sides, and having four 90° angles (Equilateral parallelogram) (Transparency 8)

B. Rectangle--A plane figure bound by parallel sides of different lengths to form opposite sides that are equal, and having four 90° angles (Transparency 8)

C. Cone--A solid figure with a circle as its base, and a curved surface tapering evenly to the vertex, so that any point on the surface is in a straight line between the circumference of the base and the vertex (Transparency 8)

D. Conic sections--Curves produced by a plane when it intersects a right circular cone (Transparency 8)

(NOTE: Types of curves produced are the circle, ellipse, hyperbola, and parabola.)

INFORMATION SHEET

E. Parabola--A curve generated by a point moving so that its distance from a fixed point is equal to its distance from a fixed line (Transparency 8)

F. Helix--Generated by a point moving along and around the surface of a cone or cylinder with a uniform angular velocity about the axis, and with a uniform linear velocity in the direction of the axis (Transparency 9)

G. Cycloid--A curve generated by a point located on the circumference of a circle as the circle rolls along a straight line (Transparency 9)

H. Quadrilateral--A plane figure bound by four straight sides (Transparency 10)

I. Parallelogram--A plane figure bound by four straight sides with the opposite sides parallel (Transparency 10)

J. Prism--A solid figure whose plane bases are parallel equal polygons and whose faces are parallelograms (Transparency 11)

K. Pyramid--A solid figure with a polygon for a base, with triangular lateral faces that intersect at a common point called a vertex (Transparency 11)

L. Involute--A curve traced by a point on a thread or string, as the thread or string unwinds from a line (Transparencies 12 and 13)

VI. Polygons and diagonals and descriptions (Transparencies 14 and 15)

A. Polygon--A plane figure with more than three straight sides

B. Diagonals--Lines connecting opposite nonsymmetrical corners of a polygon

C. Regular polygon--A plane figure with equal straight sides and equal angles; it can be circumscribed around, or inscribed in a circle

D. Pentagon--A polygon that has five equal sides and five equal angles

E. Hexagon--A polygon that has six equal sides and six equal angles

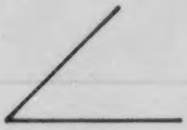
F. Octagon--A polygon that has eight equal sides and eight equal angles

VII. Basic geometric shapes

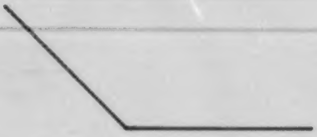
A. Straight angle-- ______________________

INFORMATION SHEET

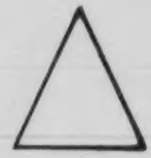
B. Acute angle--



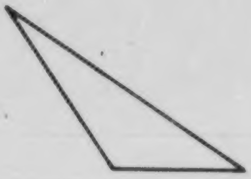
C. Obtuse angle--



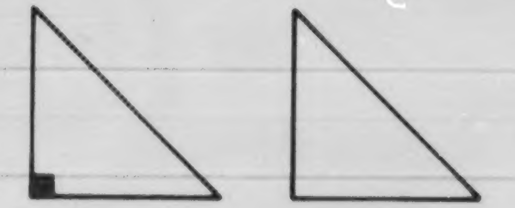
D. Isosceles triangle--



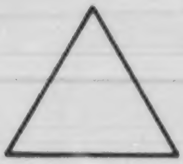
E. Scalene triangle--



F. Right triangle--

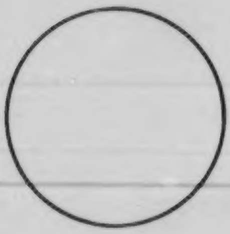


G. Equilateral triangle--

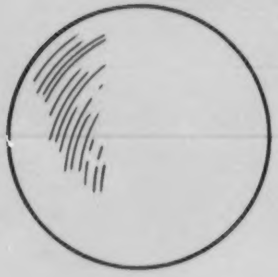


INFORMATION SHEET

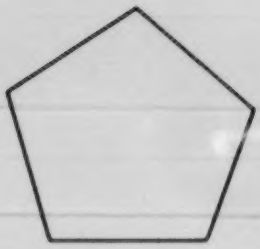
H. Circle--



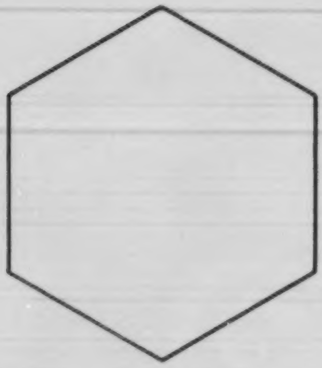
I. Sphere--



J. Pentagon--

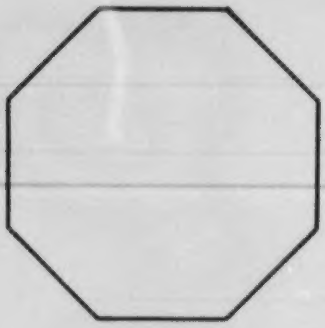


K. Hexagon--



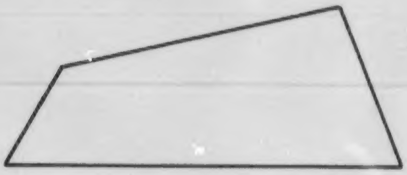
INFORMATION SHEET

L. Octagon--

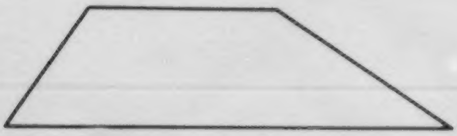


M. Quadrilaterals

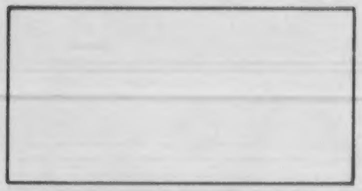
1. Trapezium--



2. Trapezoid--



3. Rectangle--



INFORMATION SHEET

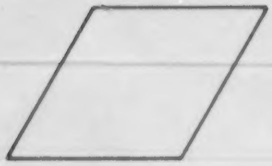
4. Square--

N. Parallelograms

1. Equilateral

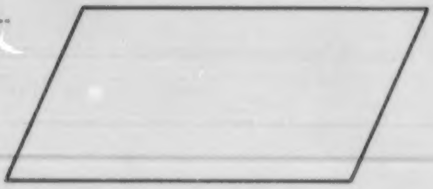
   a. Square--

   b. Rhombus--

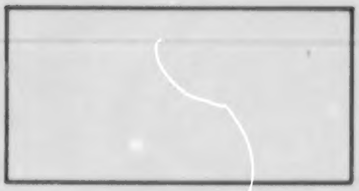


INFORMATION SHEET

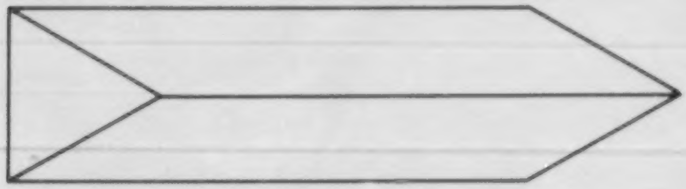
2. Rhomboid--



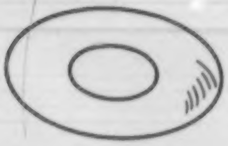
3. Rectangle--



O. Prism--



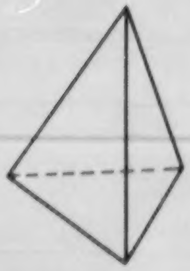
P. Torus--



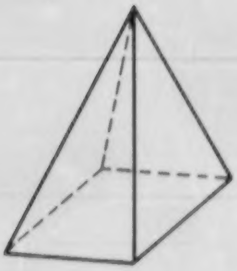
INFORMATION SHEET

Q. Pyramids

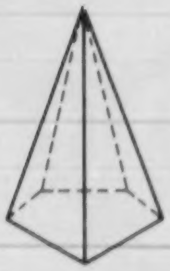
1. Right triangular--



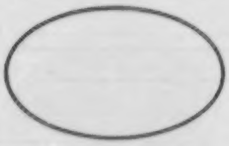
2. Right square--



3. Pentagonal--

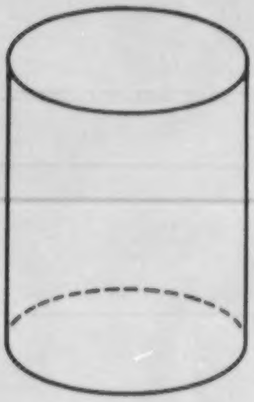


R. Ellipse--

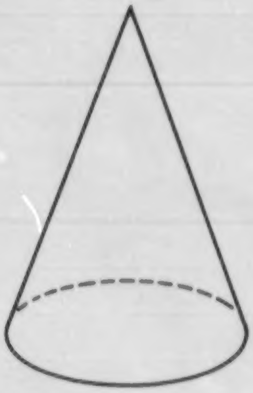


INFORMATION SHEET

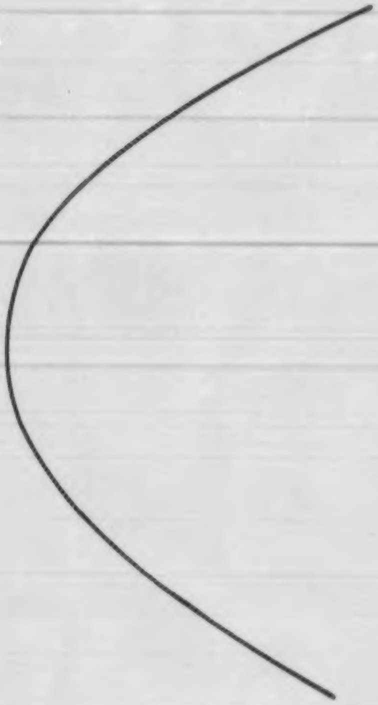
S. Cylinder--



T. Cone--

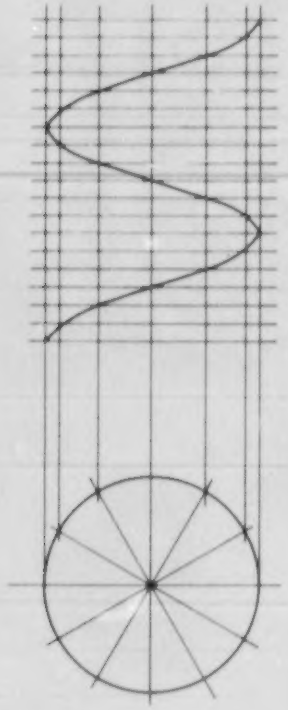


U. Parabola--

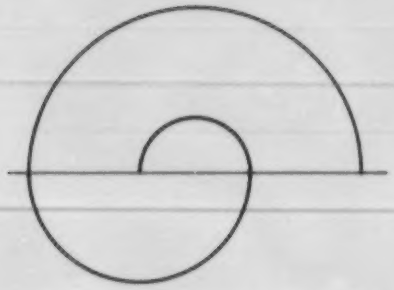


INFORMATION SHEET

V. Helix--

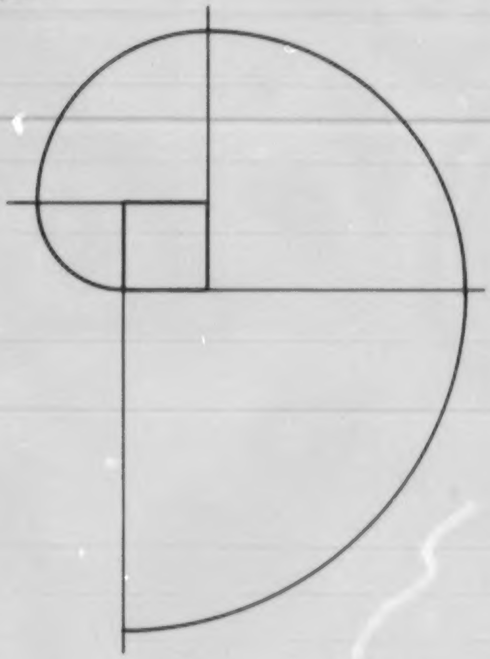


W. Involute of a line--

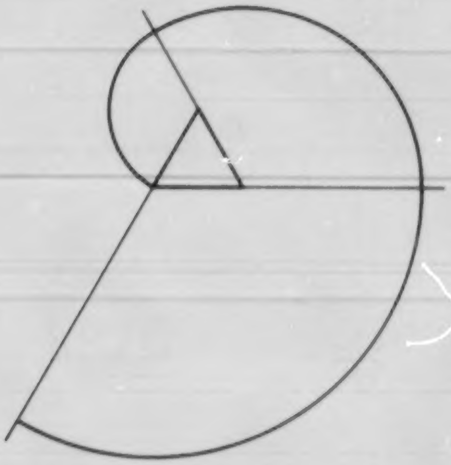


INFORMATION SHEET

X. Involute of a square--

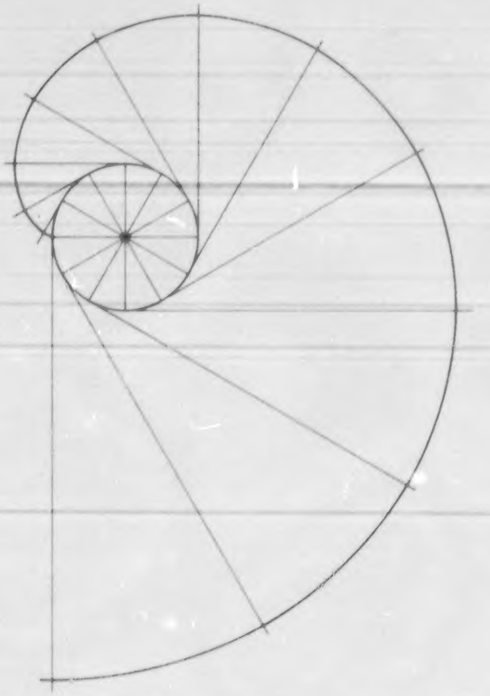


Y. Involute of a triangle--

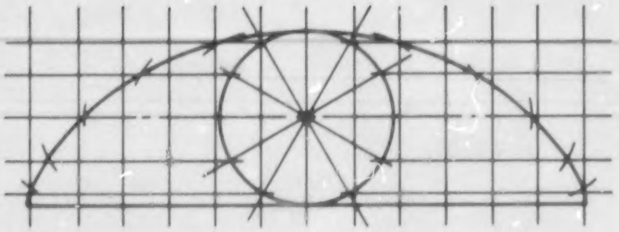


INFORMATION SHEET

Z. Involute of a circle--



AA. Cycloid--



INFORMATION SHEET

VIII. Geometric terms and symbols

A. Perpendicular-- ⊥

B. Parallel-- ||

C. Angle (singular)-- ∠

D. Angles (plural)-- ∠s

E. Less than-- <

F. Greater than-- >

G. Diameter-- Φ

H. Radius-- R

IX. Three elements needed for measuring parts of a circle

A. Diameter is measured on a straight line passing through the center point of the circle and extending to the circumference

B. Radius is measured on a straight line from the center of the circle to any point on the circumference; equals one-half the diameter

C. Circumference is measured by multiplying the diameter of the circle by π (3.1415926 or 3.14)

X. Three elements needed for interpreting degrees in a circle

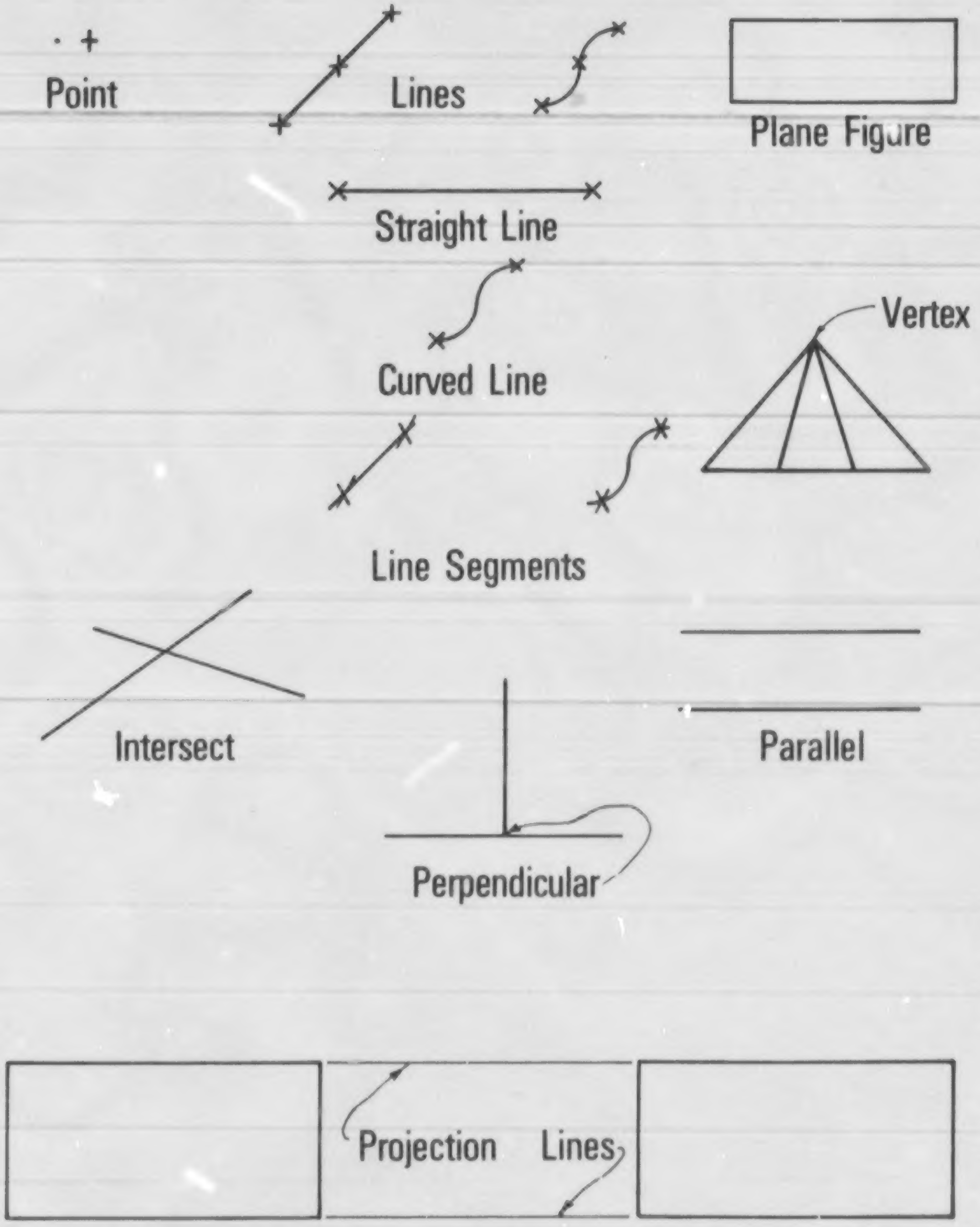
A. A full circle has 360 degrees, written as 360°

B. Each degree is divided into 60 minutes, written as 60'

C. Each minute is divided into 60 seconds, written as 60"

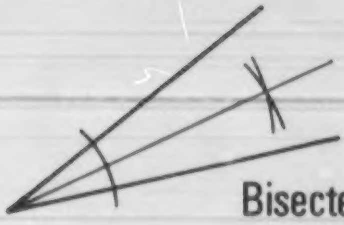
Example: 52° 14' 5" would be read as fifty-two degrees, 14 minutes, 5 seconds

Basic Geometric Shapes and Terms

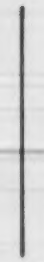

Point
Lines
Plane Figure
Straight Line
Curved Line
Vertex
Line Segments
Intersect
Parallel
Perpendicular
Projection Lines

Basic Geometric Shapes & Terms

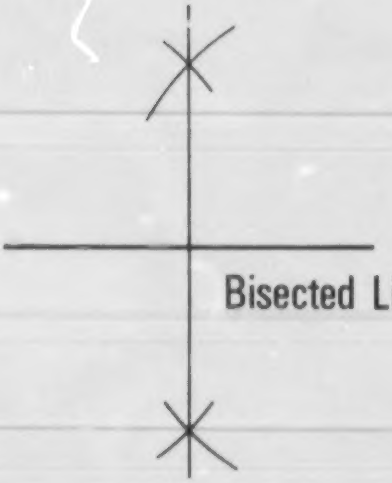
(Continued)



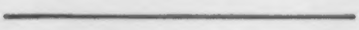
Bisected Angle



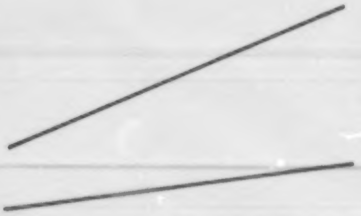
Vertical



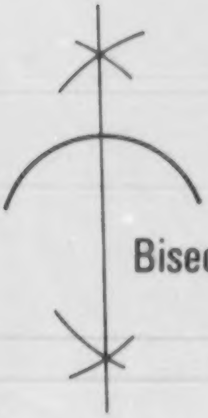
Bisected Line



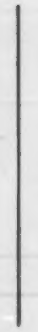
Horizontal



Skew

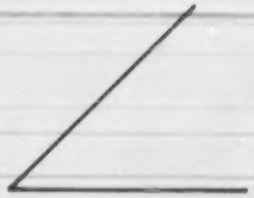


Bisected Arc

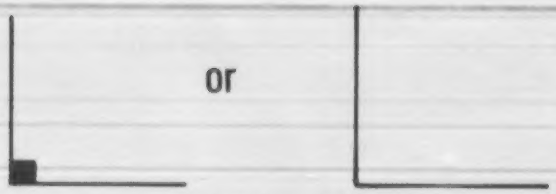


Edge

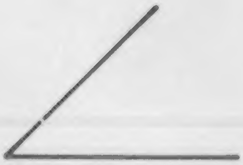
Types of Angles



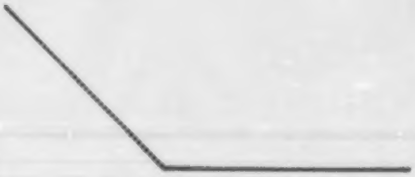
Angle



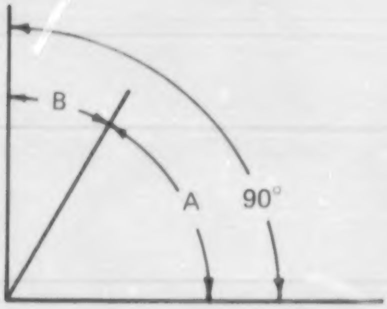
Right Angle



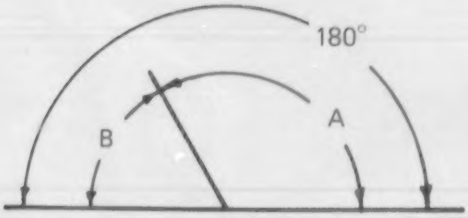
Acute Angle



Obtuse Angle

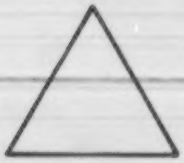


Complementary Angles

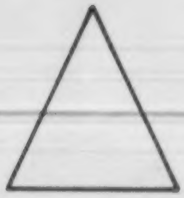


Supplementary Angles

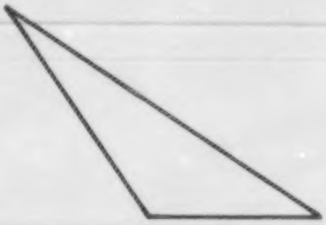
Types of Triangles



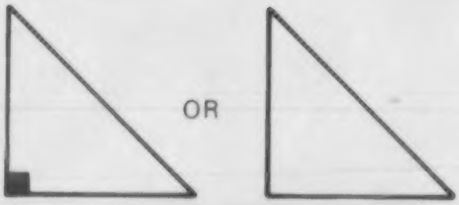
Equilateral Triangle



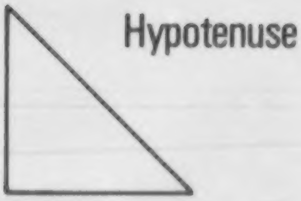
Isosceles Triangle



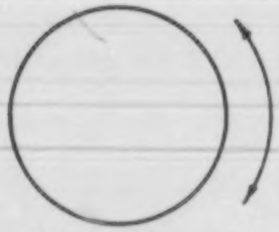
Scalene Triangle



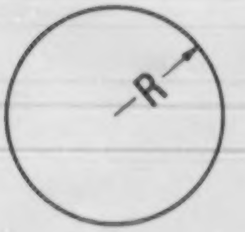
Right Triangle


Hypotenuse

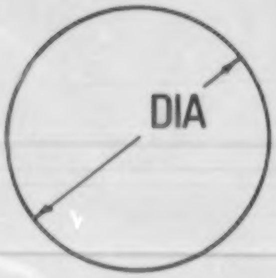
Circular Shapes



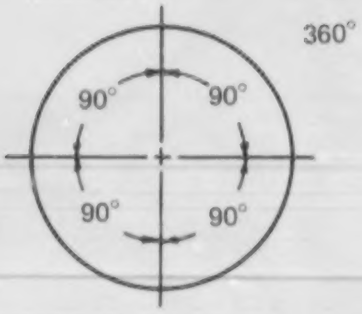
Circumference



Radius

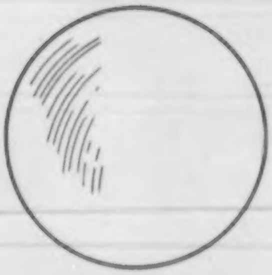


Diameter

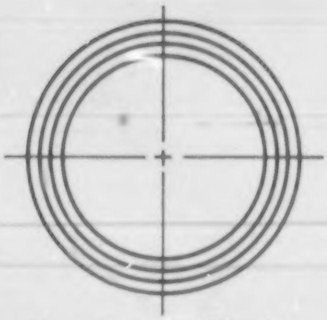

360°
90°
90°
90°
90°

Circle

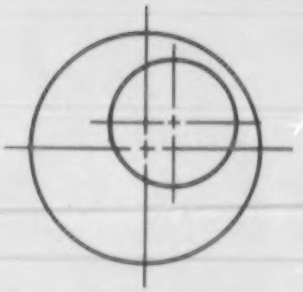
Arc



Sphere

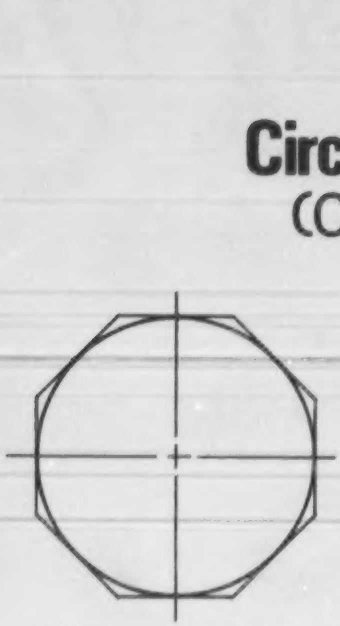


Concentric Circles

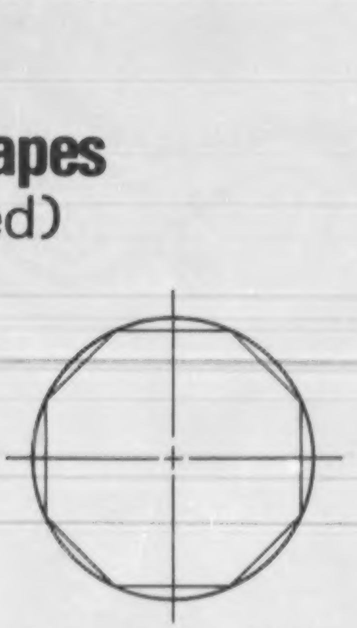


Eccentric Circles

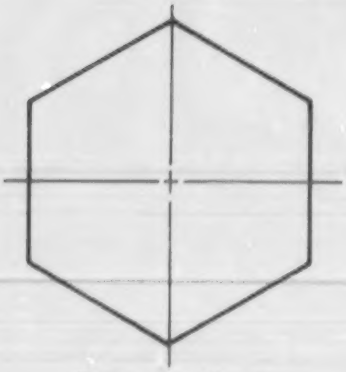
Circular Shapes
(Continued)



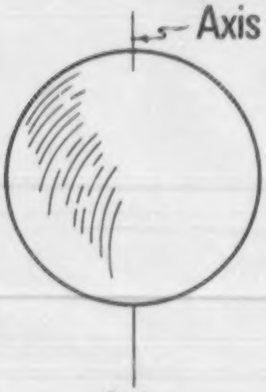
Inscribed Circle



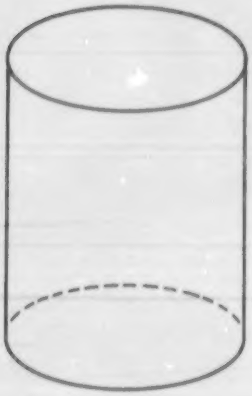
Circumscribed Circle



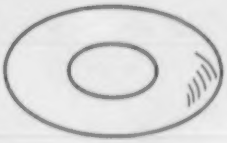
Symmetrical



Axis



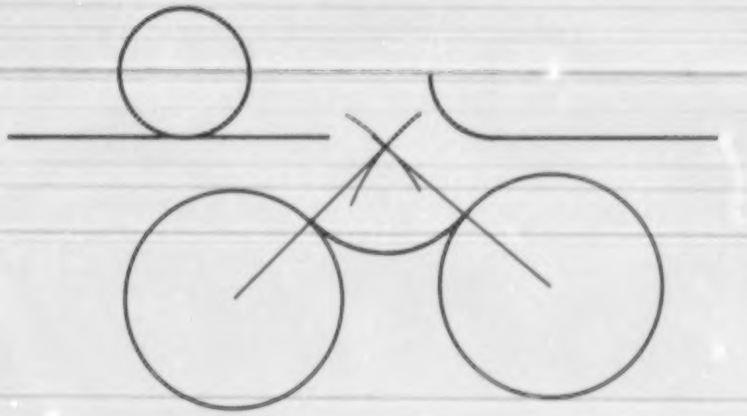
Cylinder



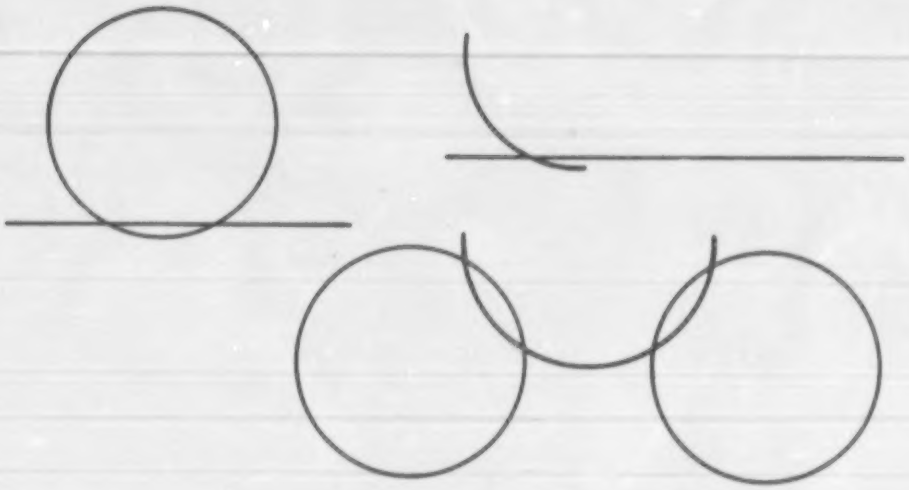
Torus

Ellipse

Circular Shapes
(Continued)



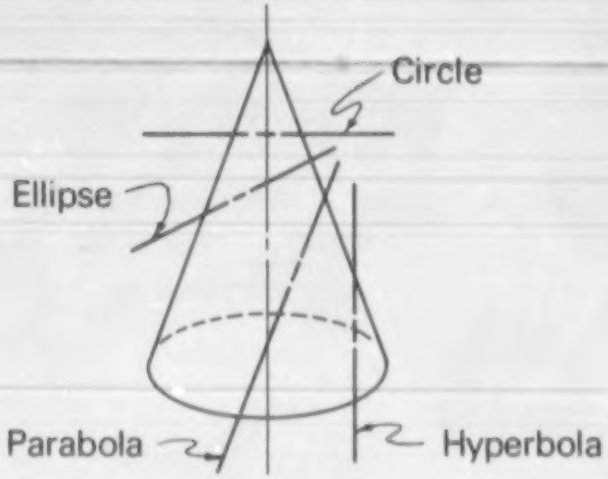
Tangent



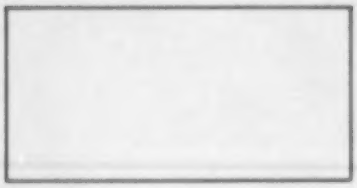
Not Tangent

Four-Sided Shapes, Cones, and Special Figures

Square

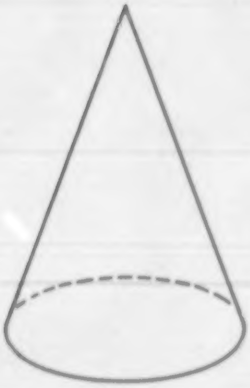

Circle
Ellipse
Parabola
Hyperbola

Conic Sections



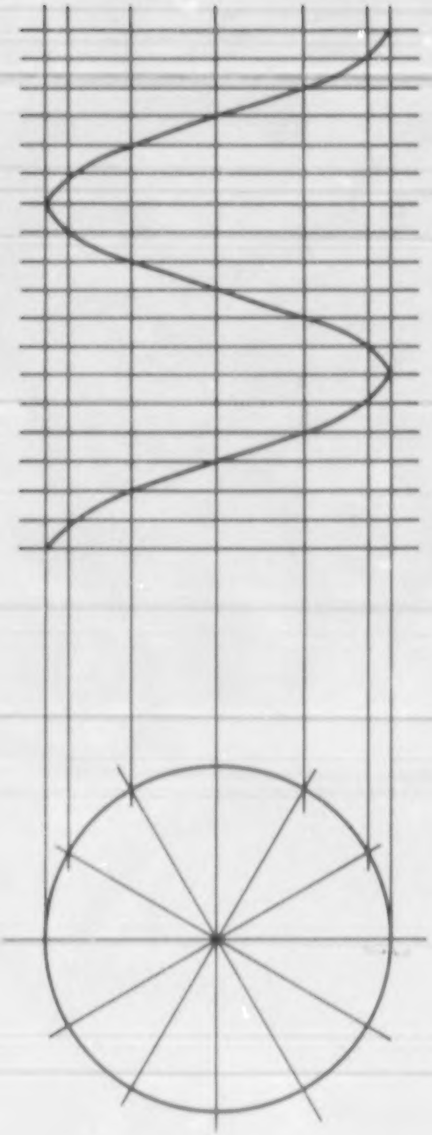
Rectangle

Parabola

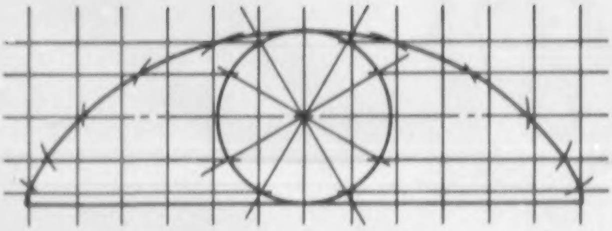


Cone

Special Figures



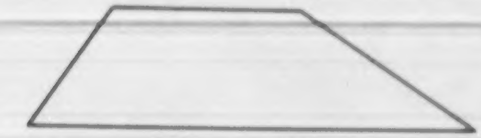
Helix



Cycloid

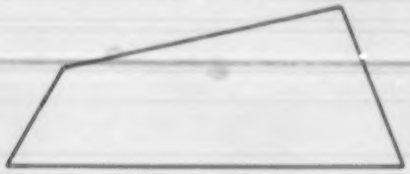
Quadrilaterals

(TWO SIDES PARALLEL)



Trapezoid

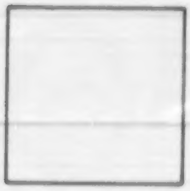
(NO SIDES PARALLEL)



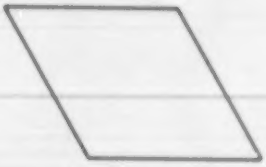
Trapezium

Parallelograms

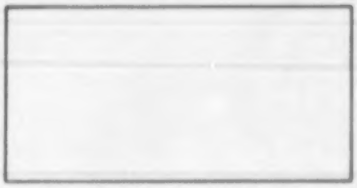
Equilateral Parallelograms



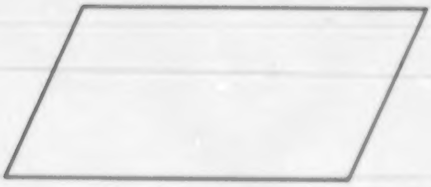
Square



Rhombus

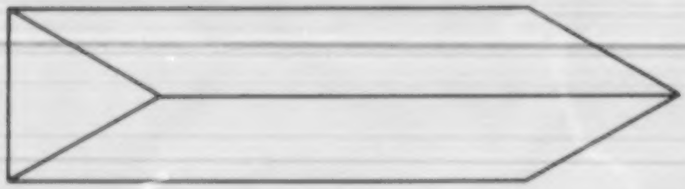


Rectangle



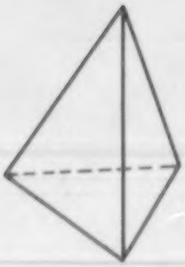
Rhomboid

Solids

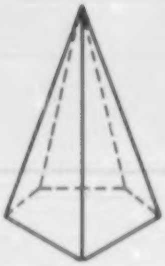


Prism

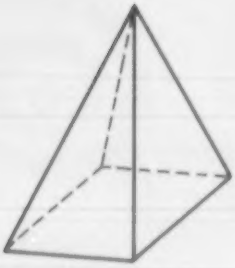
Pyramids



Right Triangular Pyramid

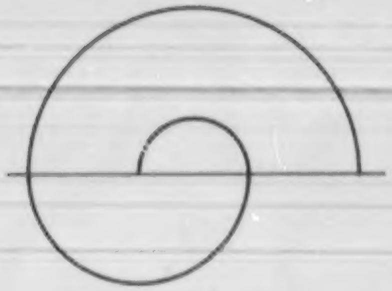


Pentagonal Pyramid

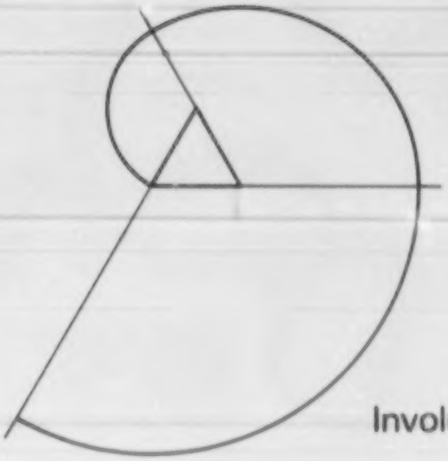


Right Square Pyramid

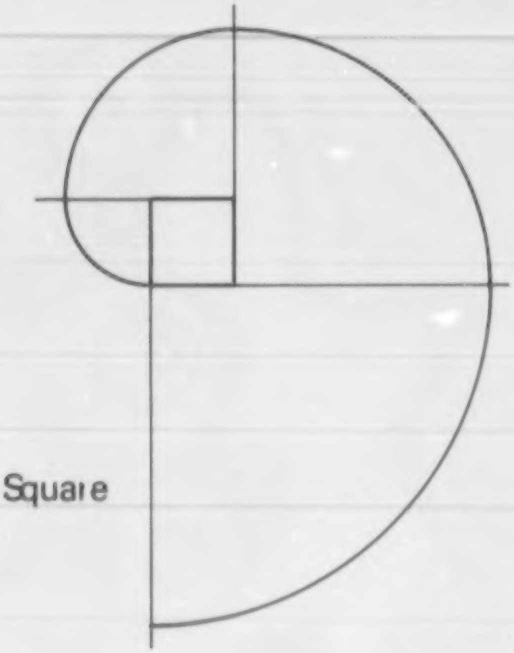
Involutes



Involute of a Line

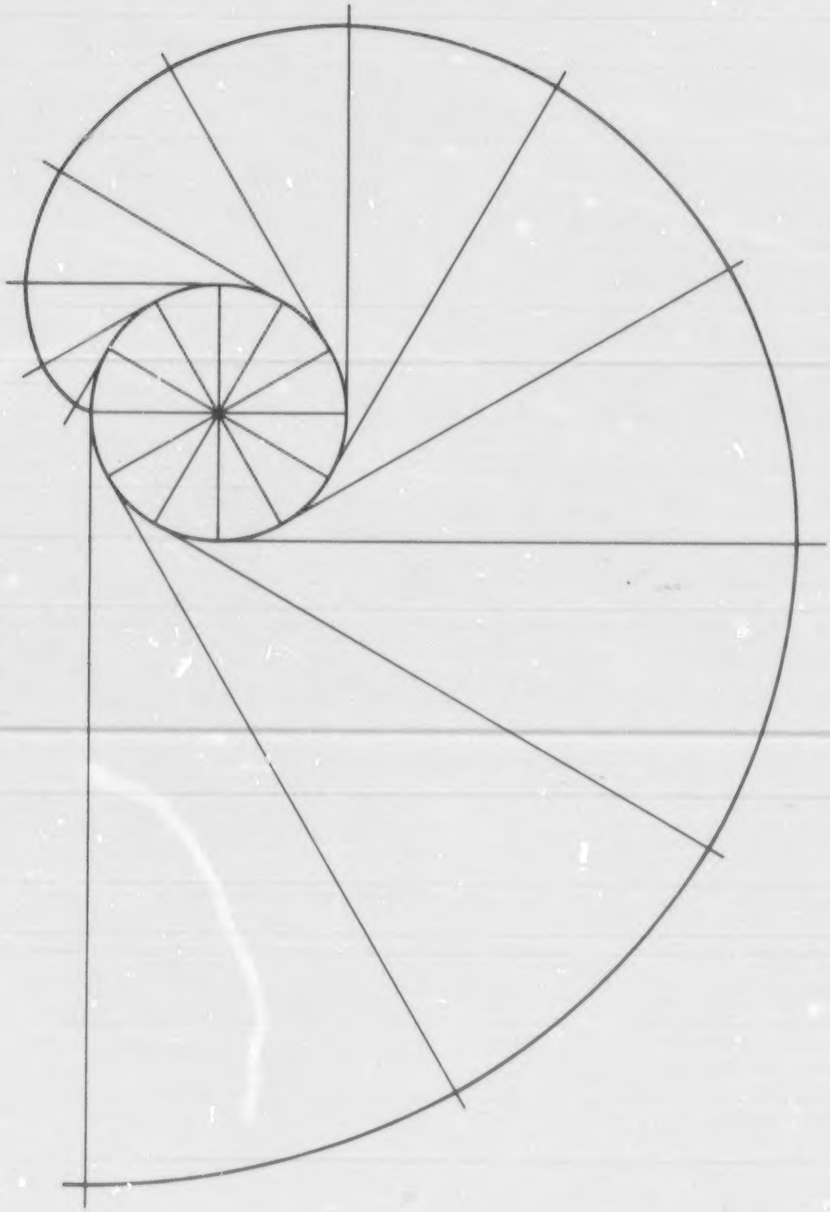


Involute of a Triangle



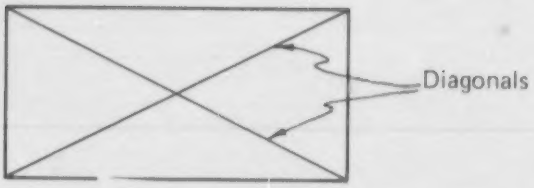
Involute of a Square

Involute of a Circle

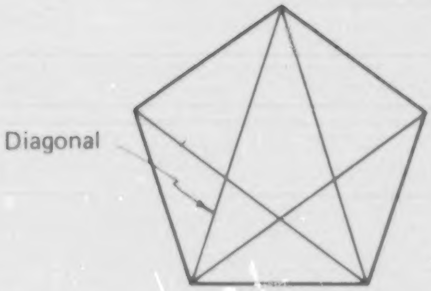


Polygons and Diagonals

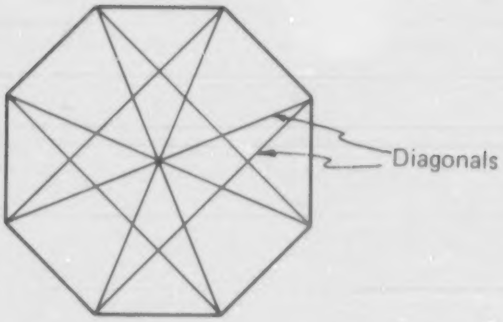
Rectangle



Rectangle

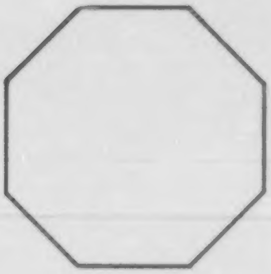


Pentagon

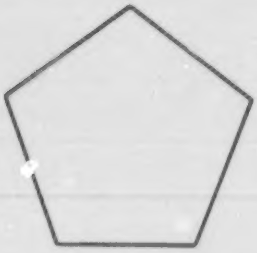


Octagon

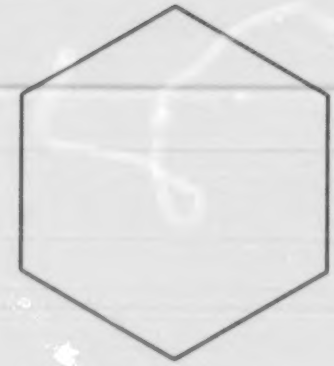
Polygons



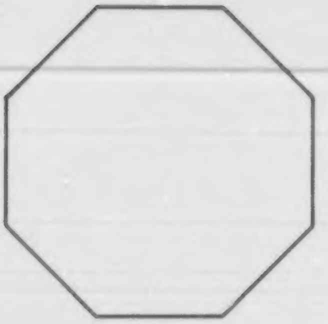
Regular Polygon



Pentagon



Hexagon



Octagon

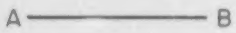
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #1--BISECT A LINE AND AN ARC

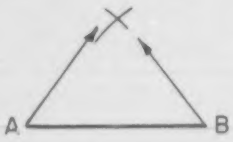
Premise: A line and an arc can be bisected with a triangle and compass by using the procedure in the following example.

Example:

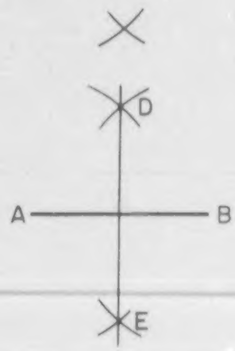
1. Use given line AB



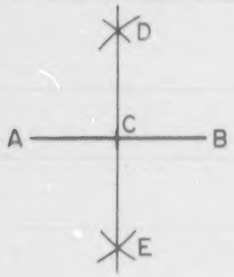
2. From A and B use compass to draw equal arcs with radius greater than half



3. Join points D and E with triangle



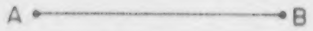
4. Mark point at C

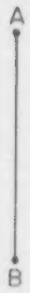


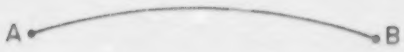
ASSIGNMENT SHEET #1

Directions: Bisect the lines AB and arc AB below. Leave all construction lines.

Problem A:







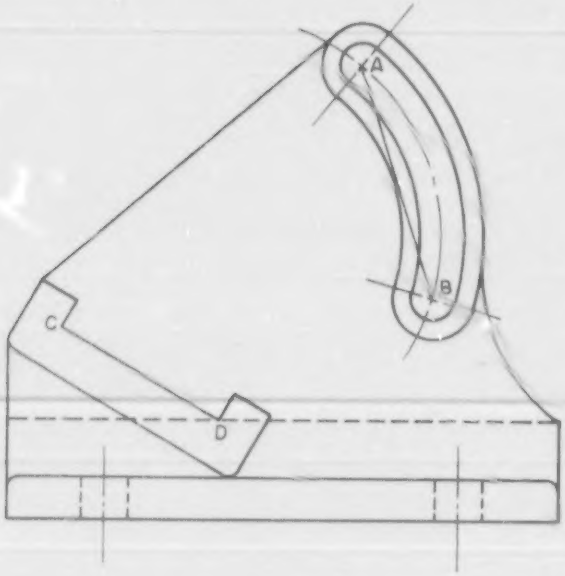
ASSIGNMENT SHEET #1

Directions: Draw construction lines lightly and do not erase them.

Problem B:

DRAW $\frac{1}{2}''$ DIA HOLE AT INTERSECTION OF PERPENDICULAR BISECTORS OF LINES AB AND CD

NOTE: DRAW HORIZONTAL AND VERTICAL CENTER LINES ONLY THROUGH THE HOLE



GRINDER ADJUSTING ARM

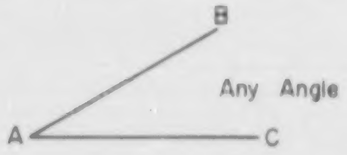
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #2--BISECT AN ANGLE

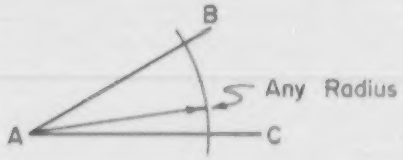
Premise: An angle can be bisected with a triangle and compass by using the procedure in the following example.

Example:

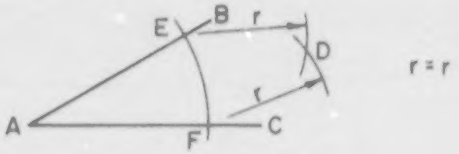
1. Use given angle BAC


B
Any Angle
A
C

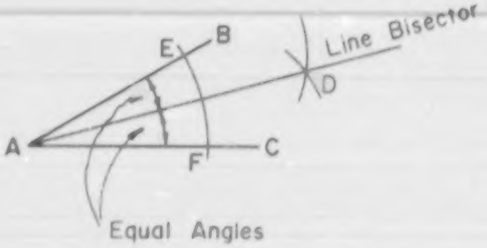
2. Strike a radius using a compass at any radius with point A as vertex


B
Any Radius
A
C

3. Strike equal arcs r with radius larger than half the distance from E to F


E
B
r
D
r
A
F
C
r = r

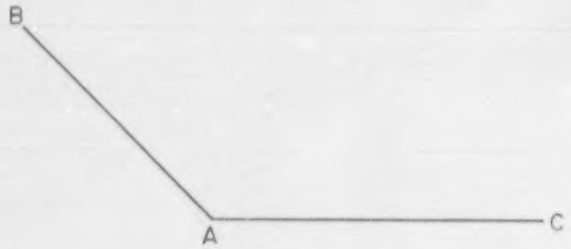
4. Draw a line from arc intersection D to vertex A

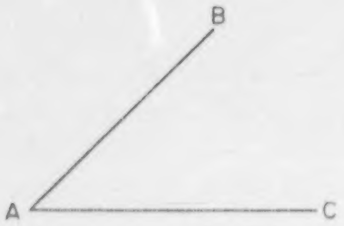

Line Bisector
E
B
D
A
F
C
Equal Angles

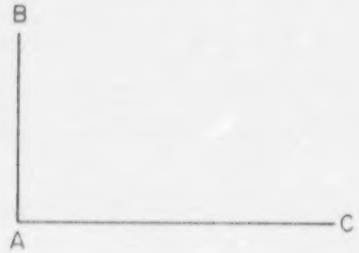
ASSIGNMENT SHEET #2

Directions: Bisect the angles below. Leave all construction lines.

Problem:







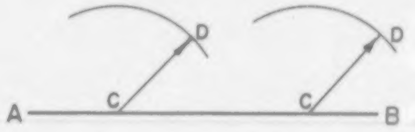
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #3--DRAW PARALLEL LINES

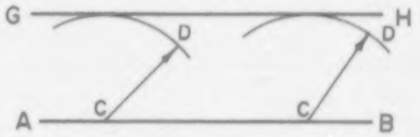
Premise: Parallel lines can be drawn with a triangle, compass, and scale by using the procedure in the following example.

Example:

1. Use given line AB



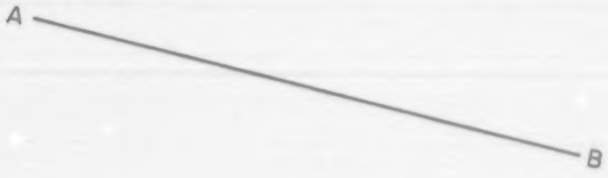
2. Set compass any desired radius CD and swing two arcs anywhare along AB



3. Construct line GH tangent to arcs CD (radius CD required distance between parallel lines)

Directions: Construct a line parallel to line AB 1" below line AB. Leave all construction lines.

Problem:



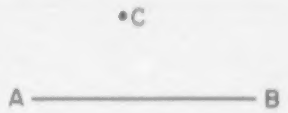
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #4--CONSTRUCT A PERPENDICULAR LINE TO A LINE FROM A POINT

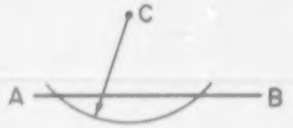
Premise: A perpendicular line can be constructed to a line from a point with a triangle and compass by using the procedure in the following example.

Example:

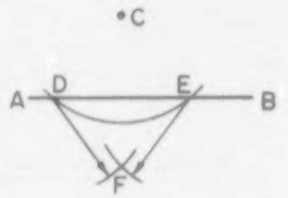
1. Use given line AB and point C



2. Swing any radius from point C as long as it touches two points on line AB

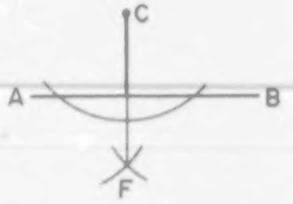


3. Swing radius DF and radius EF equal to radius DC



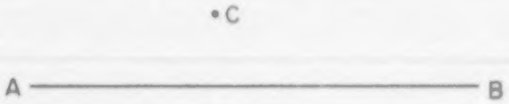
4. Connect point C with point F

   (NOTE: Line C-F is 90° to A-B.)



Direction: Construct a line perpendicular from point C to line AB. Leave all construction lines.

Problem:



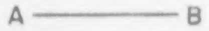
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #5–DIVIDE A LINE INTO EQUAL PARTS

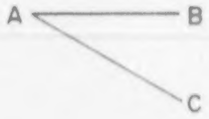
Premise: A line can be divided into equal parts with a 45° and 30° 60° triangle and a scale by using the procedure in the following example.

Example:

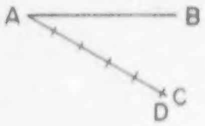
1. Use given line AB to divide into five equal parts



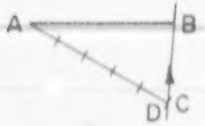
2. Draw a line at any angle and any length and label point C



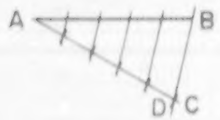
3. Use scale to lay off five equal divisions on line AC; label the last division D



4. Set triangle to project division back to line AB from point D



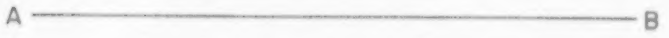
5. Set triangles to be parallel to line BD; mark divisions on line AB parallel to line BD



ASSIGNMENT SHEET #5

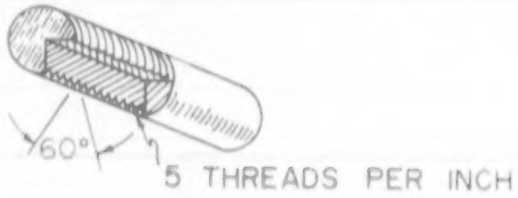
Directions: Divide line AB into seven equal divisions. Leave all construction lines.

Problem A:

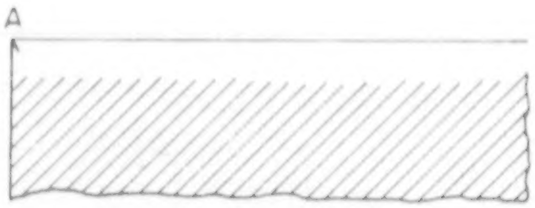


Directions: Divide horizontal line into five equal parts per inch starting at point A. Draw 60° V's as shown in the following threaded rod. Draw construction lines lightly and do not erase them. Complete section lines.

THREADED ROD



Problem B:



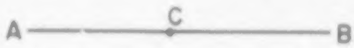
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #6--DRAW A LINE PERPENDICULAR THROUGH A POINT ON A LINE

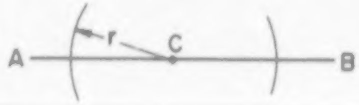
Premise: A line can be drawn perpendicularly through a point on a line with a triangle, compass, and scale by using the procedure in the following example.

Example:

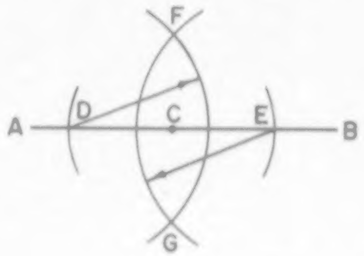
1. Use given line AB with point C located on line AB



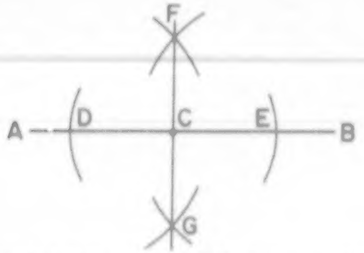
2. Set compass at any radius r and swing arc through line AB from point C



3. Set compass at distance greater than DC and swing arcs from D and E to form points F and G

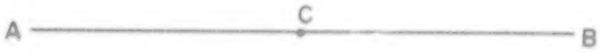


4. Connect points F and G through C



Directions: Draw a line perpendicular through point C on line AB. Leave all construction lines.

Problem:



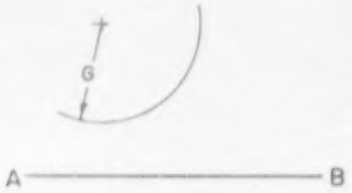
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #7–DRAW AN ARC TANGENT TO A STRAIGHT LINE AND AN ARC

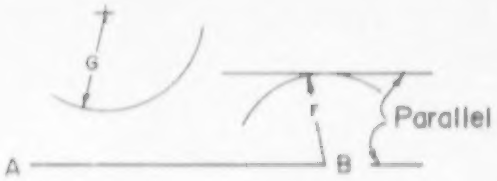
Premise: An arc tangent can be drawn to a straight line and an arc with a triangle, compass, and scale by using the procedure in the following example.

Example:

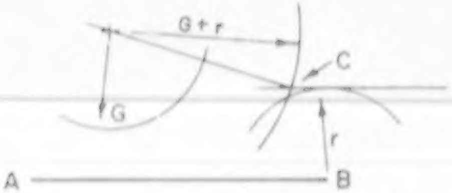
1. Use given arc with radius G and straight line AB

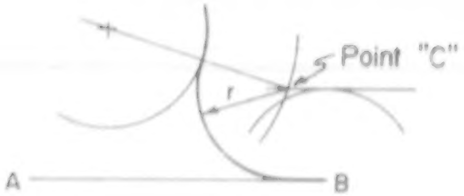


2. Swing given arc r from point B and draw a parallel line tangent to arc r



3. Add radius G to radius r and swing arc G+r to point C from point G
4. Draw line from the center point of radius G and G+r to point C to obtain tangency point



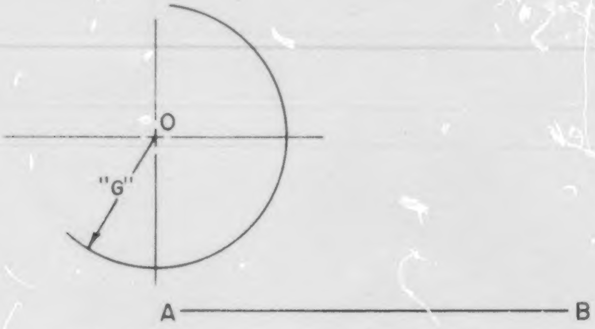


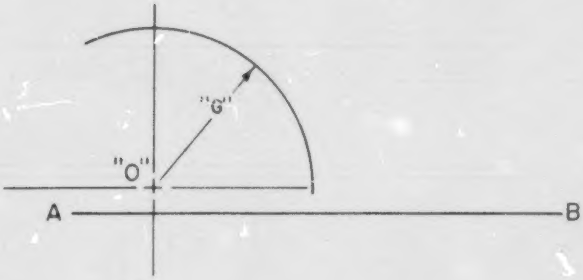
5. With center C and given radius r, draw required tangent arc between the line AB and arc

ASSIGNMENT SHEET #7

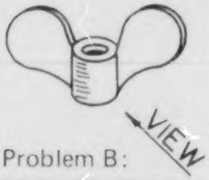
Directions: Connect line AB to arc OG with 1" R arc. Leave all construction lines.

Problem A:

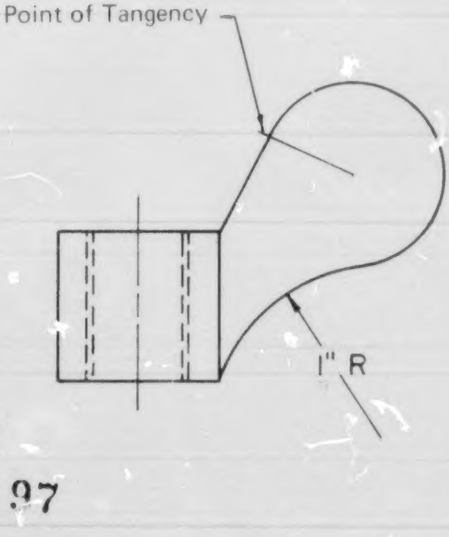




Directions: Complete the drawing of a wing nut and mark all points of tangency. Draw construction lines lightly and do not erase them.



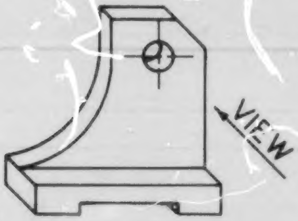
Problem B:


Point of Tangency
1" R

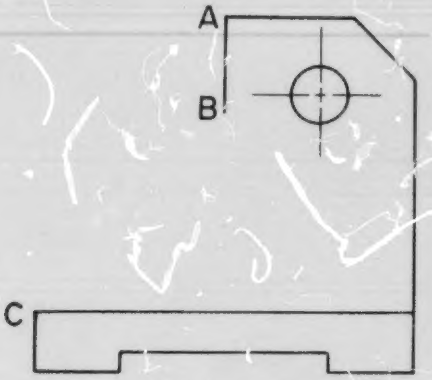
There are ___ points of tangency on this wing nut

ASSIGNMENT SHEET #7

Directions: Draw arc tangent to line AB at B, and through point C, as shown in the following bracket. Draw construction lines lightly and do not erase them.



Problem C:



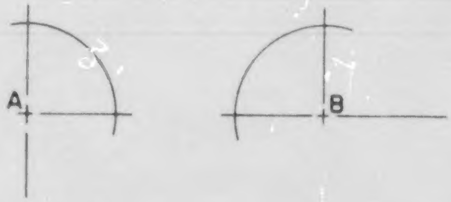
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #8--DRAW AN ARC TANGENT TO TWO ARCS

Premise: An arc tangent can be drawn to two arcs with a triangle, compass, and scale by using the procedure in the following example.

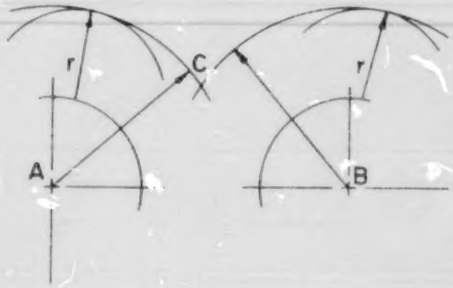
Example:

1. Use given arcs with centers A and B, and required radius r

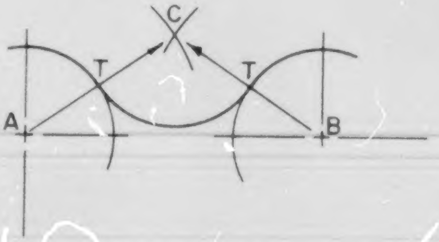


   a. Swing arcs r using any point on circles as center point

   b. Swing arc AC and arc BC tangent to given r arcs



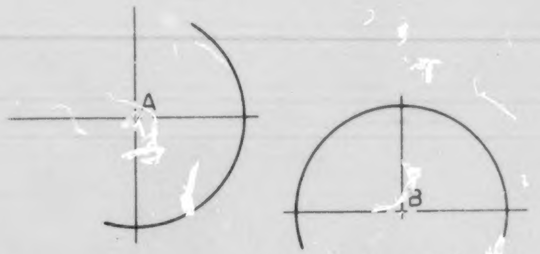
2. Draw lines of centers AC and BC to locate points of tangency T, and draw required tangent arc between the points of tangency, as shown from center C



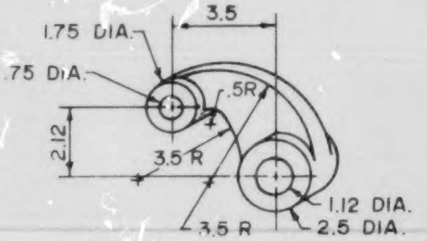
ASSIGNMENT SHEET #8

Directions: Connect the two circles with 1/2" diameter circle. Leave all construction lines.

Problem A:



Directions: Complete the drawing of a toggle link as shown in the following drawing. Draw on size "A" vellum using title block determined by the instructor. Mark points of tangency. Do not use arithmetic to add or subtract radii; do it graphically. Draw construction lines lightly and do not erase them.



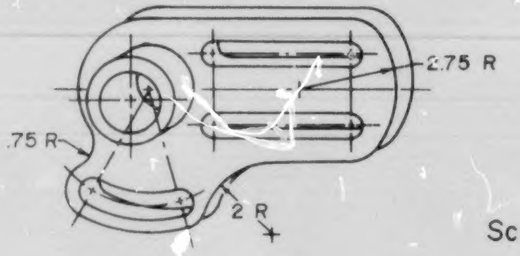
Scale: Full size on vellum

Problem B:

There are ___ tangency points
on this view

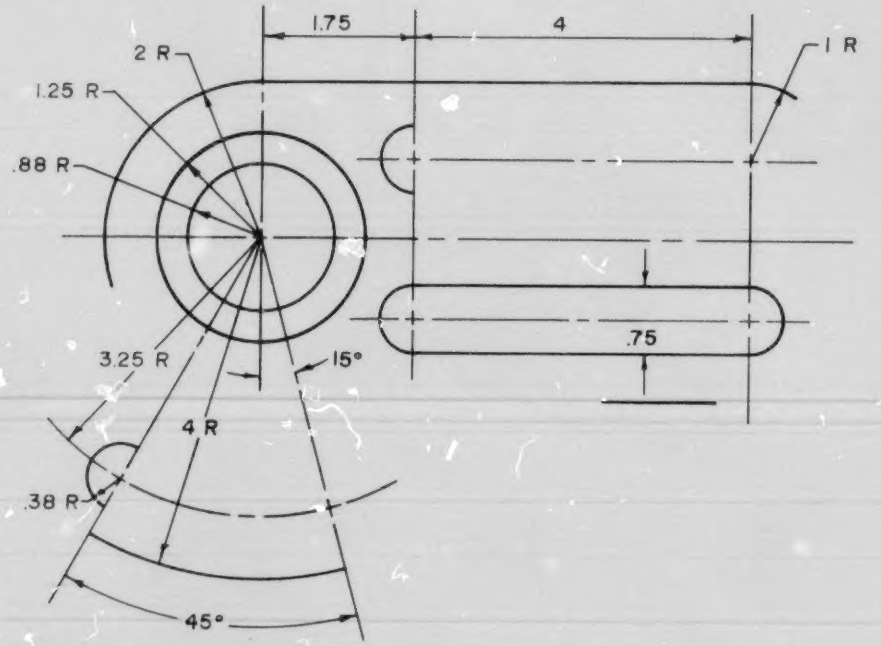
ASSIGNMENT SHEET #8

Directions: Complete the drawing of an operating arm as shown in the following drawing. Draw on size "A" vellum using title block determined by the instructor. Mark points of tangency. Draw construction lines lightly and do not erase them.



Scale: Full size on vellum

Problem C:


1.75
4
2 R
1 R
1.25 R
.88 R
.75
3.25 R
15°
4 R
.38 R
45°

There are ____ tangency points on this view

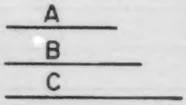
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #9--CONSTRUCT A TRIANGLE WITH SIDES GIVEN

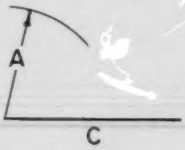
Premise: A triangle can be constructed with sides given with a triangle and compass by using the procedure in the following example.

Example:

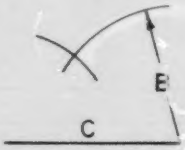
1. Use given sides A, B, and C



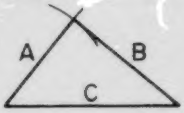
2. Draw one side, the length of C, in desired position, and strike arc with radius equal to given side A



3. Strike arc with radius equal to given side B

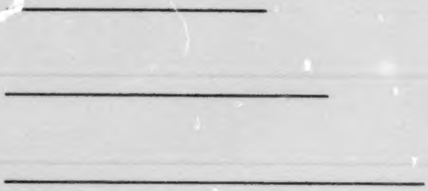


4. Draw sides A and B from intersection of arcs, as shown



Directions: Construct a triangle using the three lines given below. Leave all construction lines.

Problem:



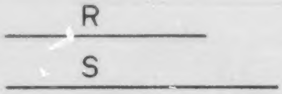
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #10--CONSTRUCT A RIGHT TRIANGLE

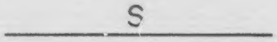
Premise: A right triangle can be constructed with a triangle and compass by using the procedure in the following example.

Example:

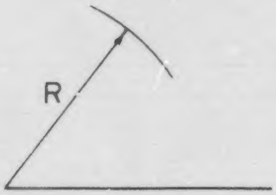
1. Use given sides R and S



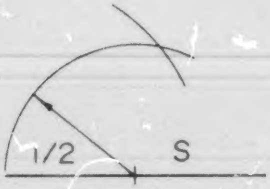
2. Draw in line S with triangle



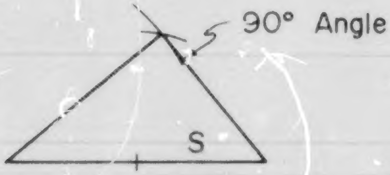
3. Swing arc with radius length as R



4. Find the middle of line S and use that point with radius 1/2 length of S to swing arc



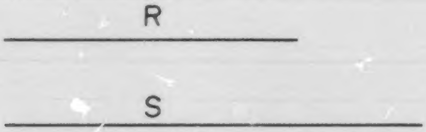
5. At point of arc intersection connect to end points of line S as shown



ASSIGNMENT SHEET #10

Directions: Construct a right triangle using the two lines given below. Leave all construction lines.

Problem:



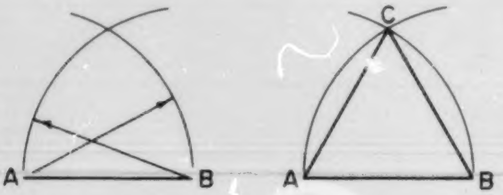
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #11--CONSTRUCT AN EQUILATERAL TRIANGLE WITH ONE SIDE GIVEN

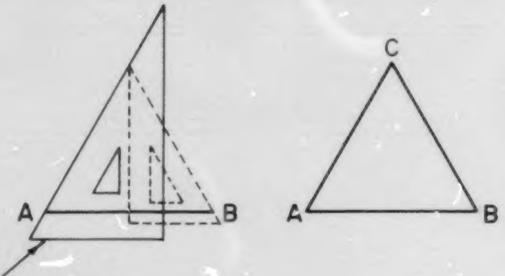
Premise: An equilateral triangle with one side given can be constructed with a 30° 60° triangle or compass by using the procedure in the following example.

Example:

1. Compass method
   a. With A and B as centers and AB as radius, strike arcs to intersect at C
   b. Draw lines AC and BC to complete the triangle



2. Triangle method--Use 60° triangle to right of A and left of B to intersect at C



Note: triangle is parallel to line AB

Directions: Construct an equilateral triangle with side AB given. Use both methods and leave all construction lines.

Problem:

A ———————— B
COMPASS

A ———————— B
TRIANGLE

GEOMETRIC CONSTRUCTIONS
UNIT II

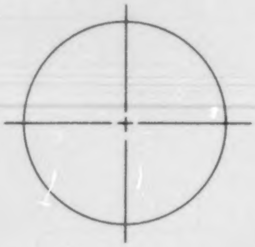
ASSIGNMENT SHEET #12--INSCRIBE A HEXAGON INSIDE A CIRCLE

Premise: A hexagon can be inscribed inside a circle with a 30° 60° triangle by using the procedure in the following example.

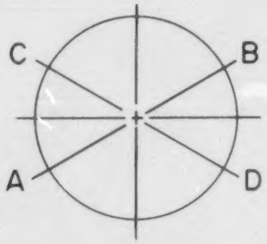
Example:

1. Use given circle diameter equal to required distance across corners of hexagon

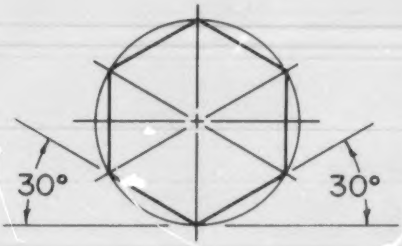
2. Draw vertical and horizontal center lines through circle



3. Use 30° triangle to construct diagonals AB and CD at 30° with horizontal through center point

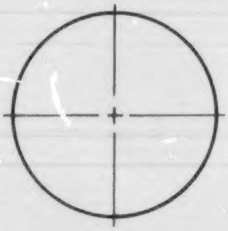


4. Use 30° triangle to construct sides



Directions: Draw a hexagon in the circle below. Leave all construction lines.

Problem:



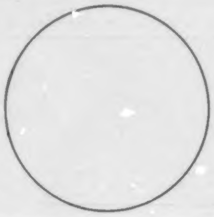
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #13--CONSTRUCT A HEXAGON WITH THE DISTANCE ACROSS THE FLAT SIDES GIVEN

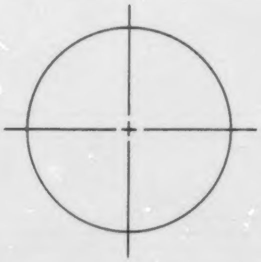
Premise: A hexagon with the distance across the flat sides given can be constructed with a 30° 60° triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given circle diameter or distance across hexagon flats (1 3/16")

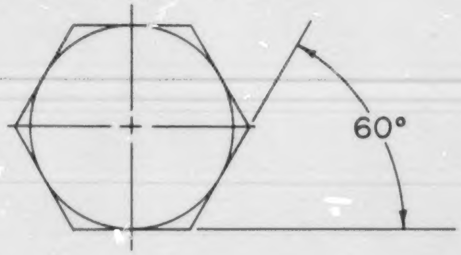


2. Put in vertical and horizontal center lines

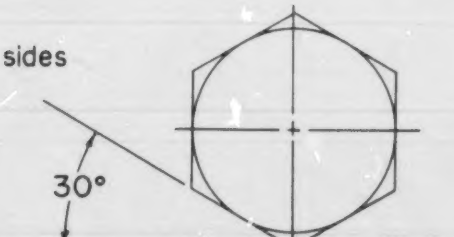


3. With the 30° 60° triangle and parallel bar or drafting machine, draw the six sides tangent to the circle; flats can be on sides or on top and bottom

Flats on top and bottom



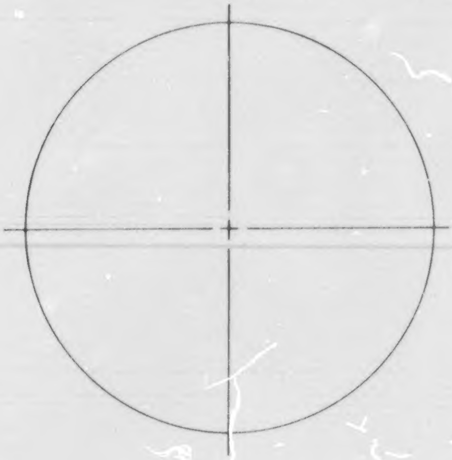
Flats on sides



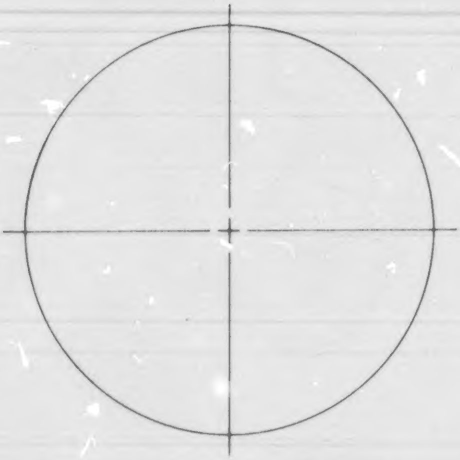
ASSIGNMENT SHEET #13

Directions: Construct a hexagon using this circle as the distance across flats. Leave all construction lines.

Problem A: Put flats on top and bottom

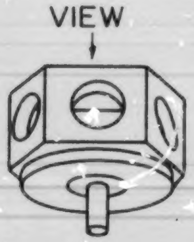


Problem B: Put flats on sides



ASSIGNMENT SHEET #13

Directions: Draw hexagons and omit holes for the following hex turret. Scale is 1/8 size (1 1/2" = 1'-0"). Have 16" across external flats and 13" across internal flats. Draw construction lines lightly and do not erase them.



Problem C:

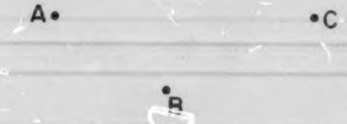
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #14--CONSTRUCT A CIRCLE THROUGH THREE GIVEN POINTS

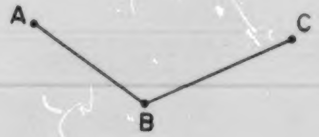
Premise: A circle can be constructed through three given points with a triangle and compass by using the procedure in the following example.

Example:

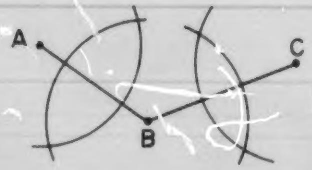
1. Use given points A, B, and C which are not in a straight line



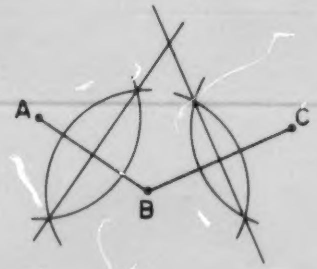
2. Connect lines AB and BC



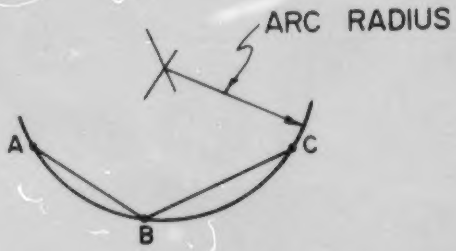
3. Find perpendicular bisectors of lines AB and BC; swing arcs as shown



4. Extend bisector lines until they intersect; this will be center point of circle



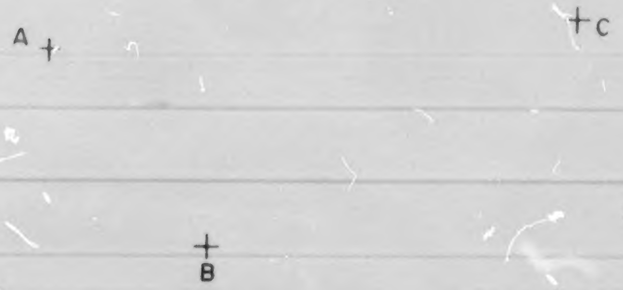
5. Use this point as center of circle radius



ASSIGNMENT SHEET #14

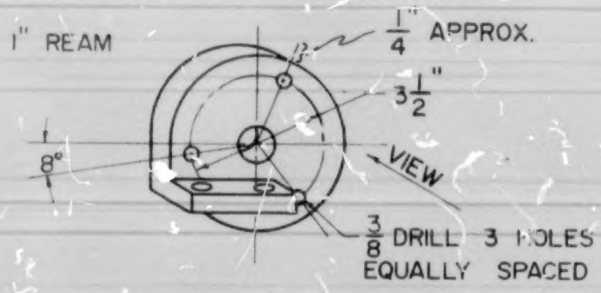
Directions: Construct a circle below that will pass through the three points given. Leave all construction lines.

Problem A:

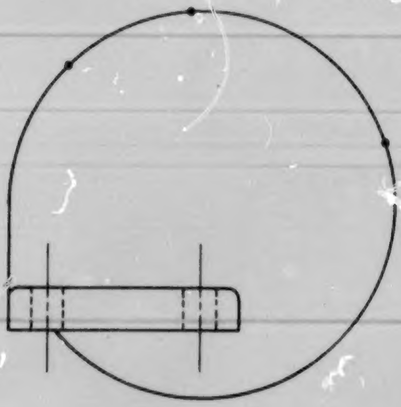


ASSIGNMENT SHEET #14

Directions: Complete the view of the bracket by finding the center of the circle through the three points given. Draw all center lines in pictorial. Scale is 1/2 size. Draw construction lines lightly and do not erase them.


1" REAM
$\frac{1}{4}$" APPROX.
$3\frac{1}{2}$"
8°
VIEW
$\frac{3}{8}$ DRILL 3 HOLES EQUALLY SPACED

Problem 8:



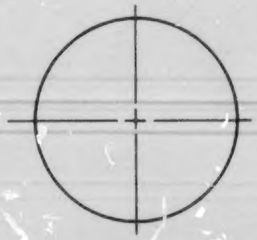
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #15--CONSTRUCT A PENTAGON BY INSCRIBING

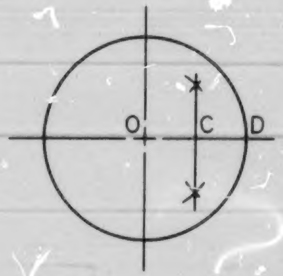
Premise: A pentagon can be constructed with a triangle and compass by using the inscribing procedure in the following example.

Example:

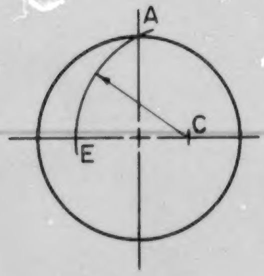
1. Use given circle



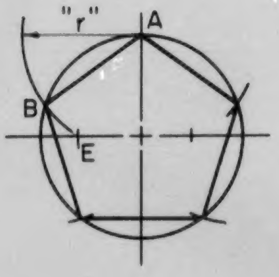
2. Bisect radius OD at C



3. With C as center and CA as radius, strike arc AE



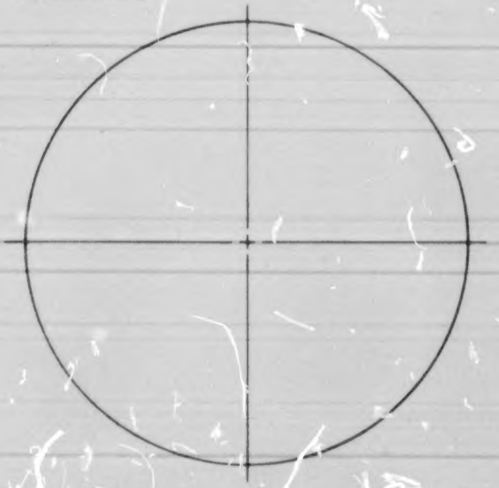
4. With A as center and AE as radius, strike arc EB
5. Draw line AB; then set off distances AB around the circumference of the circle using compass and draw the sides through these points

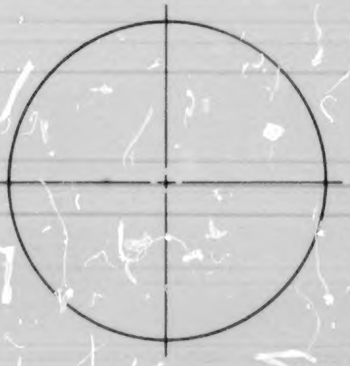


ASSIGNMENT SHEET #15

Directions: Inscribe a pentagon in the circles below. Leave all construction lines.

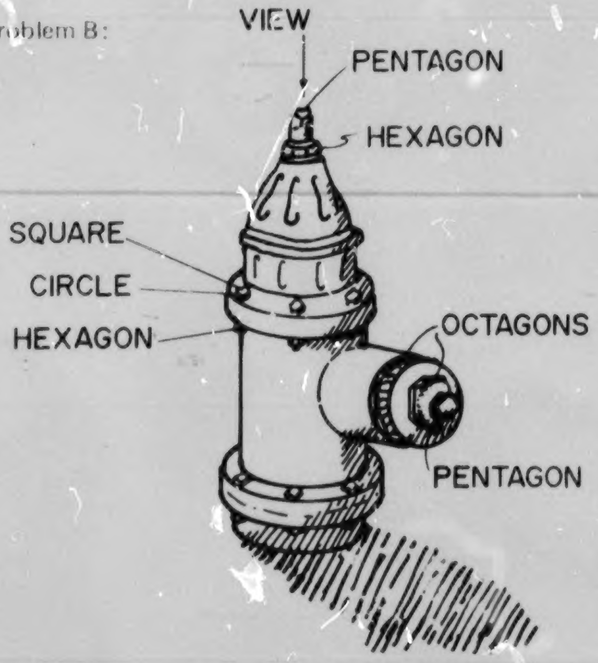
Problem A:

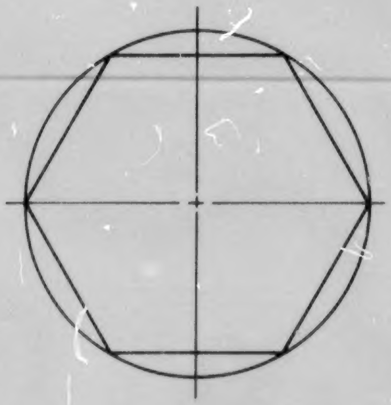




Directions: Inscribe a pentagon in a 2" circle (within hexagon) as used in the following drawing. Draw construction lines lightly and do not erase them.

Problem B:


VIEW
PENTAGON
HEXAGON
SQUARE
CIRCLE
HEXAGON
OCTAGONS
PENTAGON



GEOMETRIC CONSTRUCTIONS
UNTI II

ASSIGNMENT SHEET #16--DRAW AN ARC TANGENT TO AN ACUTE ANGLE AND AN OBTUSE ANGLE

Premise: An arc tangent can be drawn to an acute angle and an obtuse angle with a triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

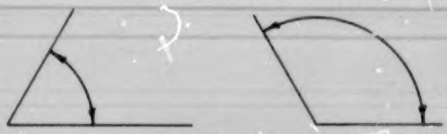
ACUTE ANGLE

OBTUSE ANGLE

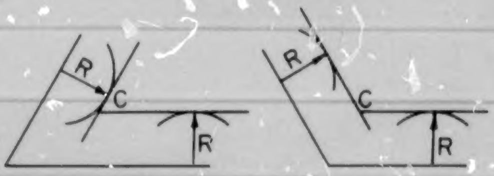
Example:

1. Use given acute angle and obtuse angle

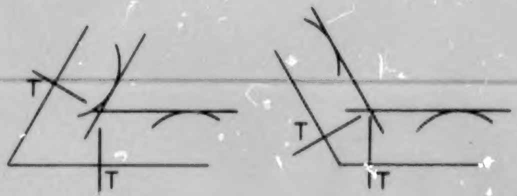
   (NOTE: In this example every step will be performed on the acute angle on the left and on the obtuse angle on the right.)



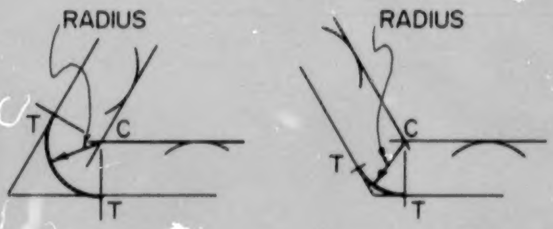
2. Draw lines parallel to given lines at distance R from them, to intersect at C, the required center



3. From C drop perpendiculars to the given lines respectively to locate points of tangency T



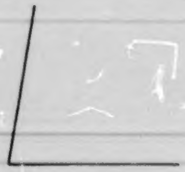
4. With C as center and with given radius R, draw required tangent arc between the points of tangency

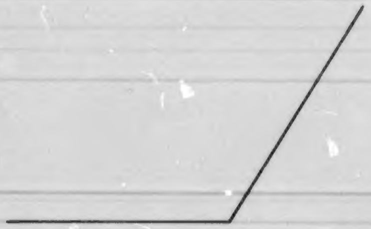


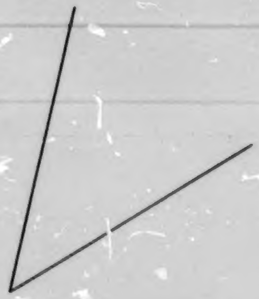
ASSIGNMENT SHEET #16

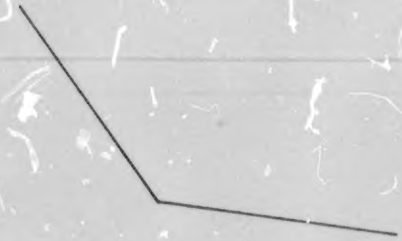
Directions: Connect the sides of the angles below with a 1/2" radius arc. Leave all construction lines.

Problem:









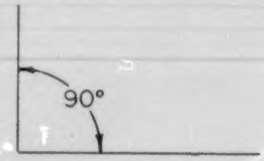
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #17--DRAW AN ARC TANGENT TO A RIGHT ANGLE

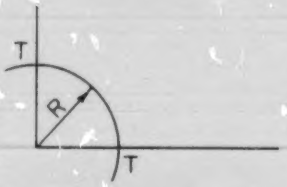
Premise: An arc tangent can be drawn to a right angle with a triangle and scale by using the procedure in the following example.

Example:

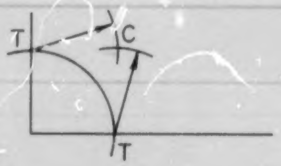
1. Use given lines at right angles to each other, any radius required



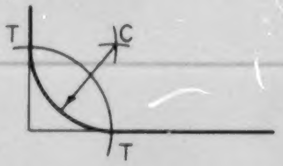
2. With given radius R, strike arc intersecting given lines at tangent points T



3. With given radius R again, and with points T as centers, strike arcs intersecting at C

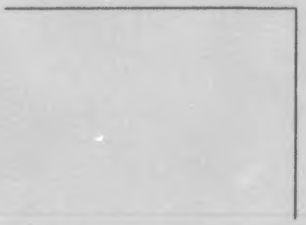


4. With C as center and given radius R, draw required tangent arc



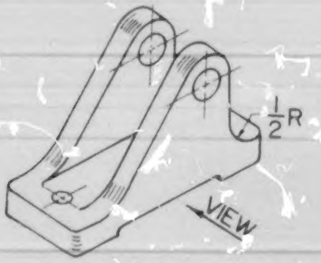
Directions: Draw a 3/4" R arc in the right angles below. Leave all construction lines.

Problem A:

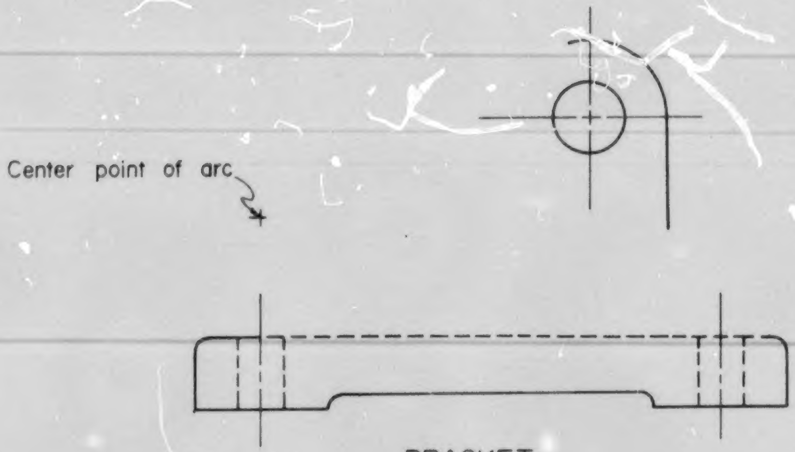


ASSIGNMENT SHEET #17

Directions: Draw arc tangents to complete the drawing as shown in the following bracket. Mark points of tangency. Draw construction lines lightly and do not erase them.


$\frac{1}{2}$R
VIEW

Problem 3:


Center point of arc

BRACKET
Scale: Full Size

There are ___
points of tangency
on this view

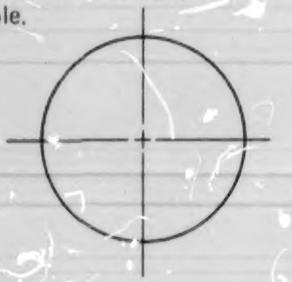
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #18--DRAW AN INVOLUTE OF A CIRCLE

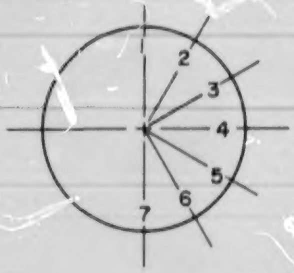
Premise: An involute of a circle can be drawn with a triangle, compass, and irregular curve by using the procedure in the following example.

Example:

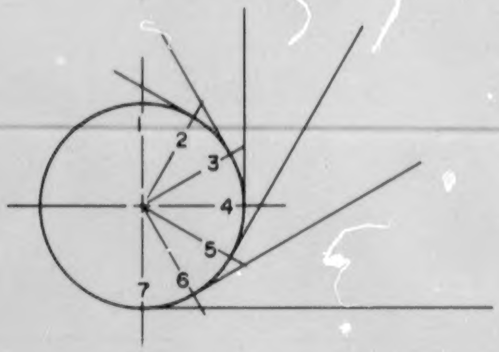
1. Use given circle diameter



2. Divide circle into a given number of equal parts; in this case six equal parts

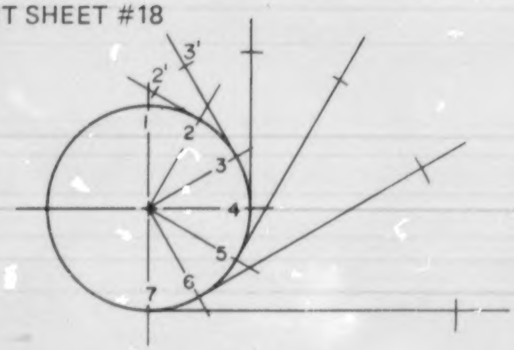


3. At each of these divisions, put in lines tangent to circle and perpendicular to radius lines

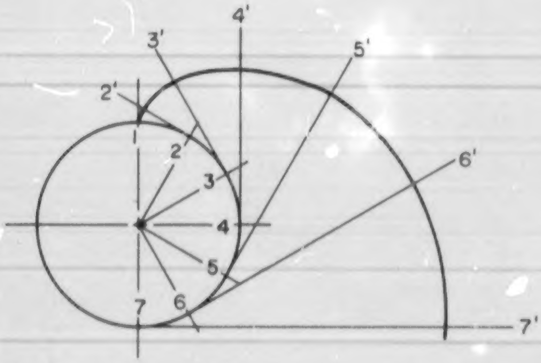


ASSIGNMENT SHEET #18

4. Lay off the length of the arc from point 1 to point 2; using 2 as center point, swing arc from 2 to 2', lay off the length of the arc from 2' to 3 and swing arc 3-3'

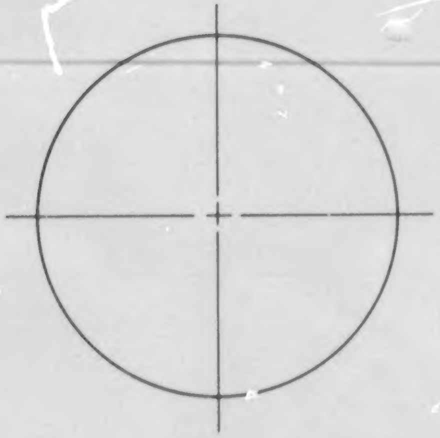


5. Continue in like manner for each point; sketch a light line through the points and darken the curve, using an irregular curve



Directions: Construct an involute of the following circle. Leave all constructions lines.

Problem:



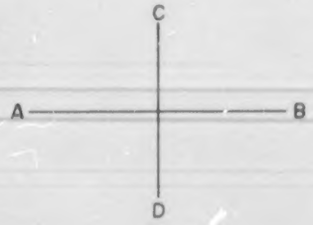
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #19--DRAW AN ELLIPSE USING THE APPROXIMATE ELLIPSE WITH COMPASS METHOD

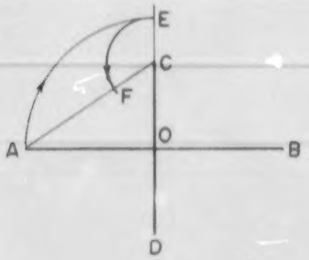
Premise: An ellipse can be drawn by the compass method with a triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given axis AB and axis CD

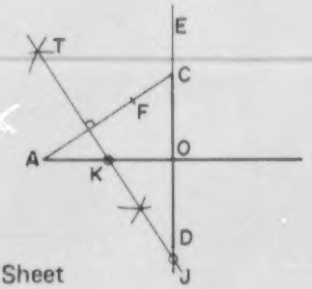


2. Draw line AC
3. With O as center and OA as radius, strike arc AE
4. With C as center and CE as radius, strike the arc EF



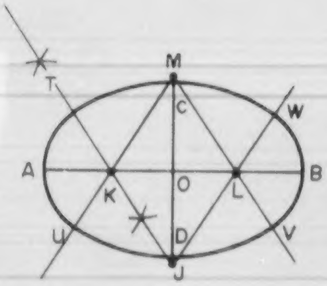
5. Draw perpendicular bisector of the line AF; the points T, K, and J where it intersects the axes, are centers of the required arcs

   (NOTE: If needed, refer to Assignment Sheet #1 for drawing a perpendicular bisector of a line.)



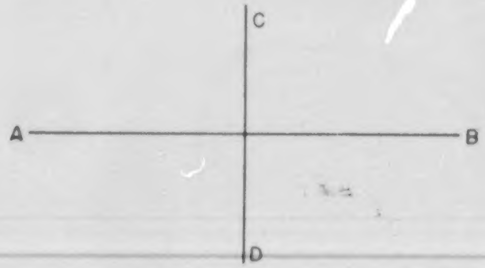
ASSIGNMENT SHEET #19

6. Find center M by measuring OJ with compass
7. Set compass point at O and strike point M
8. Find center L by measuring OK with compass
9. Set compass point at O and strike point L
10. Draw line M through point K to form point U
11. Draw line M through point L to form point V
12. Draw line J through point L to form point W
13. Keep arcs tangent as shown
14. Using K as the center point, swing arc KA from point U to point T
15. Using L as the center point, swing arc LB from point W to point V
16. Using J as the center point, swing arc JC from point T to point W
17. Using M as the center point, swing arc MD from point V to point U



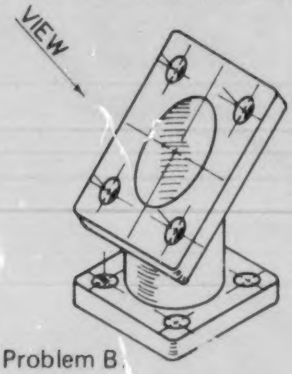
Directions: Construct an approximate ellipse of the axis lines AB and CD. Leave all construction lines.

Problem A:

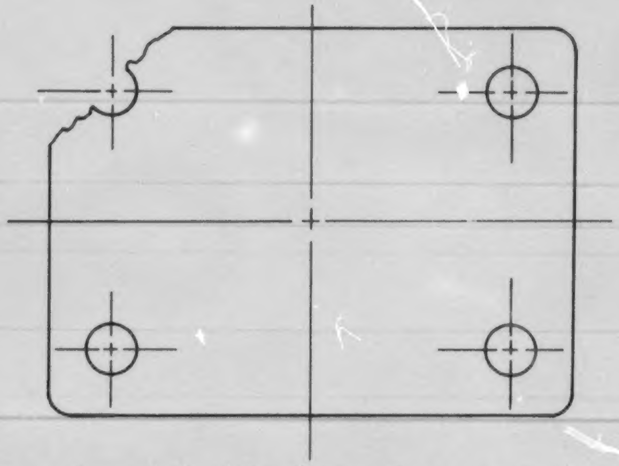


ASSIGNMENT SHEET #19

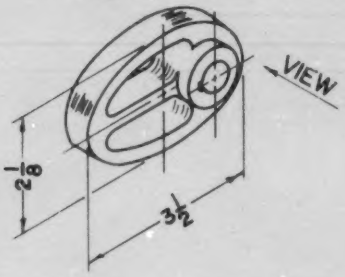
Directions: Draw an approximate ellipse 1 1/4" x 2 1/8" as shown in the following bracket. Draw construction lines lightly and do not erase them.



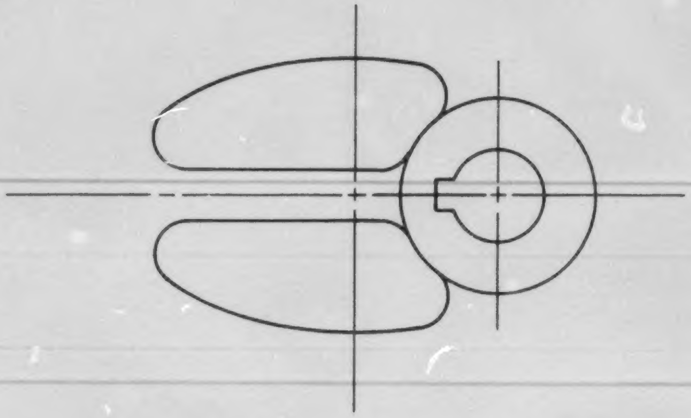
Problem B:



Directions: Draw an approximate ellipse as shown in the following cam. Draw construction lines lightly and do not erase them.



Problem C:



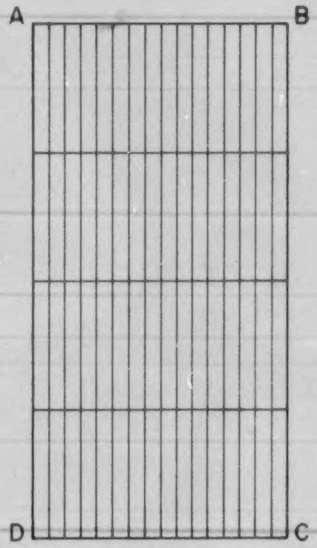
GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #20--DRAW A PARABOLA

Premise: A parabola can be drawn with a triangle, compass, irregular curve, and parallel bar or drafting machine by using the procedure in the following example

Example:

1. Use given lines ABCD



2. Divide line AD into some number of equal parts
3. Divide line AB into an equal number of parts amounting to the square of that number

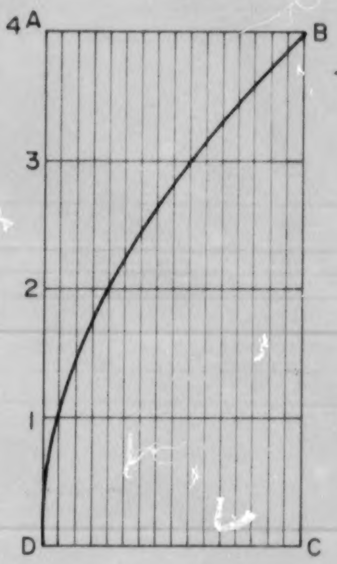
   Example: If A-D is divided into 4 equal spaces, then AB will be divided into 16 equal spaces

ASSIGNMENT SHEET #20

4. From line AD, every point on the parabola is determined by the number of spacing units equal to the square of the number on AD starting from point D which is also O

   Example: 1=1, 2=4, 3=9, 4=16

5. Sketch a light line through the points and darken the curve, using an irregular curve



Directions: Construct a parabola in the given area. Leave all construction lines.

Problem:

GEOMETRIC CONSTRUCTIONS
UNIT II

ASSIGNMENT SHEET #21--JOIN TWO POINTS WITH A PARABOLIC CURVE

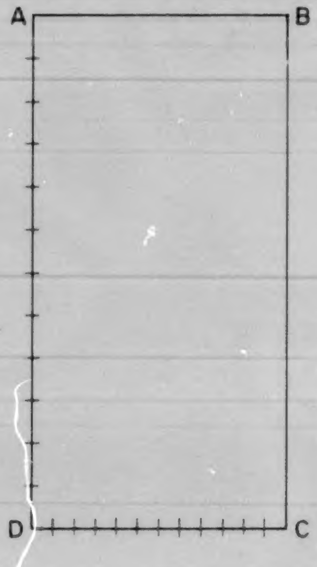
Premise: Two points can be joined in a parabolic curve with a triangle, scale, irregular curve, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given lines ABCD

2. Divide line AD into an equal number of spaces

3. Divide line DC into the same number of equal spaces

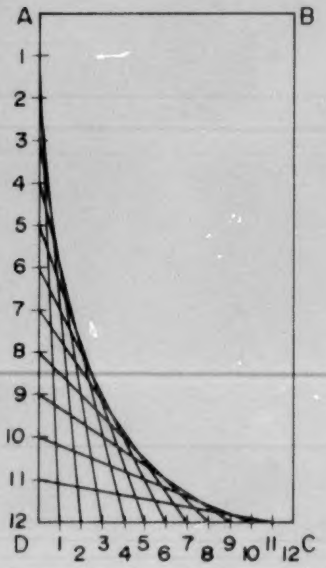


4. Number the points on AD starting at A as 0 and number the points on DC starting at D as 0

5. Draw a straight line from point 1 on line AD to point 1 on line DC

6. Then do this for each point

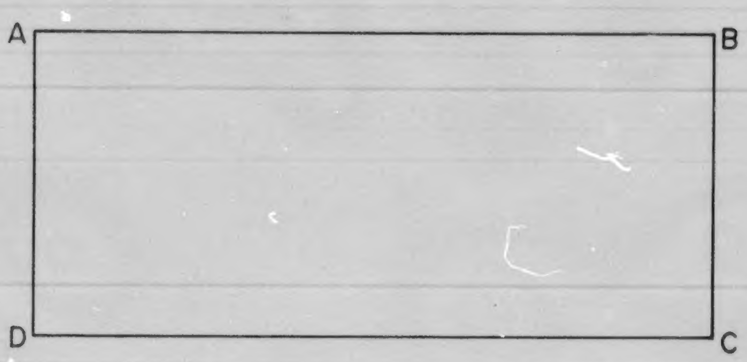
7. Darken the curve, using an irregular curve



ASSIGNMENT SHEET #21

Directions: Construct a parabolic curve from point B to point D. Leave all construction lines.

Problem:



GEOMETRIC CONSTRUCTIONS
UNIT II

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

______a. A small dot or small cross on a drawing or in space that does not have length, height, depth, or width

______b. A connection between two or more points

______c. The shortest distance between two points

______d. A line in which no segment is straight

______e. Any part of a line

______f. A flat, level, even surface such as a piece of paper lying flat on a table

______g. To cut across each other

______h. The common point where lines or surfaces intersect

______i. At 90° angles to a given plane or line

______j. Straight lines that do not meet or intersect and are an equal distance apart at all points

______k. Line used to extend from one view to another view

______l. Straight lines that do not intersect and are not parallel or in the same plane

______m. To divide into two equal parts

______n. A line straight up and down perpendicular to the horizontal plane

______o. Parallel to the plane of the horizon

______p. What appears as a line when a plane surface is perpendicular to a plane of projection

______q. All sides are equal

1. Intersect
2. Skew lines
3. Edge
4. Bisect
5. Point
6. Vertex
7. Line
8. Projection line
9. Perpendicular
10. Horizontal
11. Curved line
12. Plane figure
13. Vertical
14. Equilateral
15. Straight line
16. Parallel
17. Line segment

2. Match types of angles on the right with their correct descriptions.

_____ a. Figure formed by two intersecting lines

_____ b. A 90° angle

_____ c. An angle less than 90°

_____ d. An angle greater than 90°

_____ e. Two angles whose sum is 90°

_____ f. Two angles whose sum is 180°

1. Obtuse angle
2. Right angle
3. Supplementary angles
4. Angle
5. Complementary angles
6. Acute angle

3. Match types of triangles on the right with their correct descriptions.

_____ a. A plane figure bound by three straight sides, and three interior angles which equal 180°

_____ b. A triangle with three equal sides and three equal angles

_____ c. A triangle with two equal sides and two equal angles

_____ d. A triangle with no angles or sides equal

_____ e. A triangle with one 90° angle

1. Triangle
2. Right triangle
3. Scalene triangle
4. Equilateral triangle
5. Isosceles triangle

4. Match circular shapes on the right with their correct descriptions.

_____ a. The distance around a circle

_____ b. The distance from the center point of a circle to the outside circumference

_____ c. The distance across a circle passing through its center point

_____ d. A closed curve all points of which are an equal distance from the center

_____ e. Any portion of the circumference of a circle

_____ f. A round body such as a ball which has all points of its circumference an equal distance from its center

_____ g. Having the same point as center

_____ h. Having different points as center, one within the other

_____ i. The same on both sides of a center line

1. Tangent
2. Chord
3. Sector
4. Circumference
5. Arc
6. Quadrant
7. Symmetrical

_____ j. A figure drawn within another figure so as to touch in as many places as possible

_____ k. A figure encircled so as to touch in as many places as possible

_____ l. A straight line passing through the center of a geometric body upon which the geometric body rotates

_____ m. Meeting a curved line or surface, touching at one and only one point, but most definitely not intersecting

_____ n. A solid figure generated by a circle which is revolving on an axis which is eccentrical to the circle

_____ o. A foreshortened circle having a major diameter and a minor diameter

_____ p. A solid figure obtained by taking a rectangle by its edge and rotating it around to its parallel edge, making the ends parallel, and the circles equal

_____ q. Any straight line across a circle that does not pass through the center

_____ r. One-half of a circle

_____ s. Less than a semicircle

_____ t. One-fourth of a circle

_____ u. Less than a quadrant

8. Torus
9. Semicircle
10. Radius
11. Axis
12. Ellipse
13. Eccentric circles
14. Sphere
15. Circle
16. Diameter
17. Cylinder
18. Inscribed
19. Circumscribed
20. Concentric circles
21. Circular segment

5. Match four-sided shapes, cones, and special figures on the right with their correct descriptions.

_____ a. A plane figure bound by four equal sides, and having four 90° angles

_____ b. A plane figure bound by parallel sides of different lengths to form opposite sides that are equal, and having four 90° angles

_____ c. A solid figure with a circle as its base, and a curved surface tapering evenly to the vertex, so that any point on the surface is in a straight line between the circumference of the base and the vertex

_____ d. Curves produced by a plane when it intersects a right circular cone

1. Helix
2. Cycloid

______e. A curve generated by a point moving so that its distance from a fixed point is equal to its distance from a fixed line

______f. Generated by a point moving along and around the surface of a cone or cylinder with a uniform angular velocity about the axis, and with a uniform linear velocity in the direction of the axis

______g. A curve generated by a point located on the circumference of a circle as the circle rolls along a straight line

______h. A plane figure bound by four straight sides

______i. A plane figure bound by four straight sides with the opposite sides parallel

______j. A solid figure whose plane bases are parallel equal polygons and whose faces are parallelograms

______k. A solid figure with a polygon for a base, with triangular lateral faces that intersect at a common point called a vertex

______l. A curve traced by a point on a thread or string, as the thread or string unwinds from a line

3. Quadrilateral
4. Square
5. Involute
6. Parabola
7. Prism
8. Rectangle
9. Parallelogram
10. Cone
11. Pyramid
12. Conic sections

6. Match polygons and diagonals on the right with their correct descriptions.

______a. A plane figure with more than three straight sides

______b. Lines connecting opposite nonsymmetrical corners of a polygon

______c. A plane figure with equal straight sides and equal angles; it can be circumscribed around, or inscribed in a circle

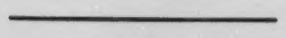
______d. A polygon that has five equal sides and five equal angles

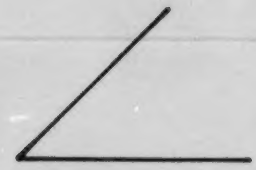
______e. A polygon that has six equal sides and six equal angles

______f. A polygon that has eight equal sides and eight equal angles

1. Hexagon
2. Diagonals
3. Octagon
4. Regular polygon
5. Polygon
6. Pentagon

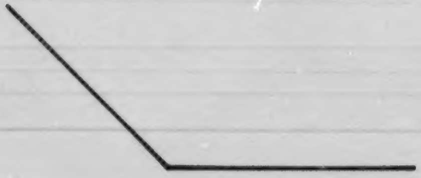
7. Identify the following basic geometric shapes.

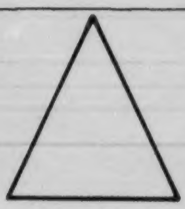




a. ____________________

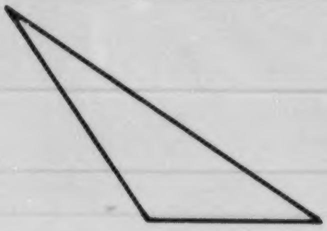
b. ____________________

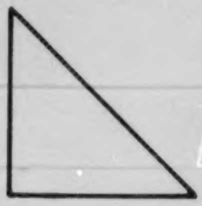




c. ____________________

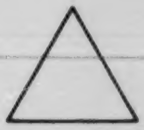
d. ____________________

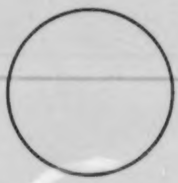




e. ____________________

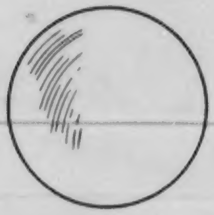
f. ____________________

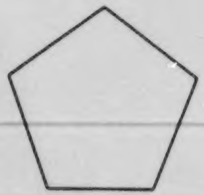




g. ____________________

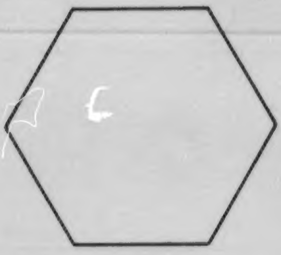
h. ____________________

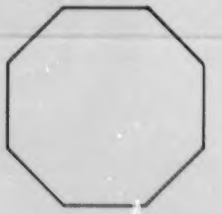




i. ____________________

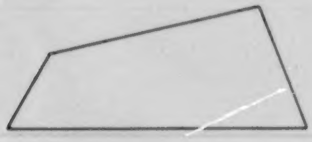
j. ____________________

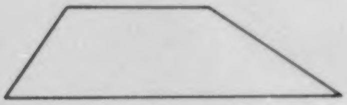




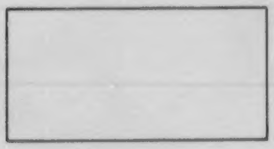
k. ____________________ l. ____________________

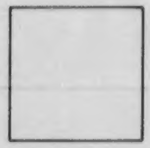
m. Quadrilaterals





1) ____________________ 2) ____________________

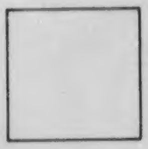


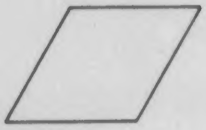


3) ____________________ 4) ____________________

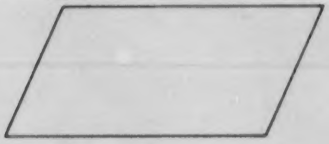
n. Parallelograms

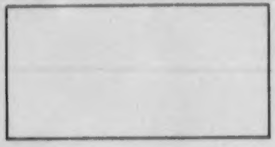
1) Equilateral



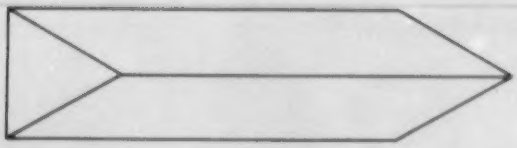


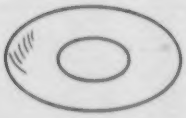
a) ____________________ b) ____________________





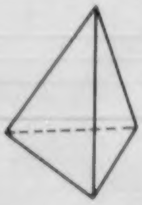
2) ____________________ 3) ____________________

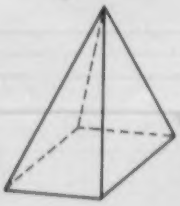




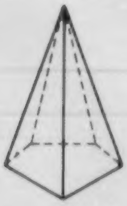
o. ______________________ p. ______________________

q. Pyramids

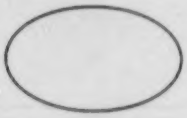




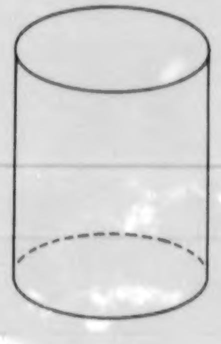
1) ______________________ 2) ______________________

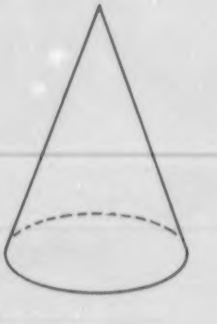


3) ______________________

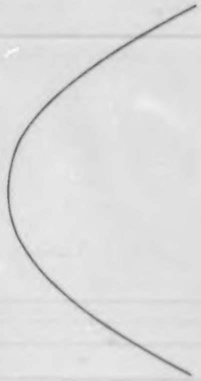


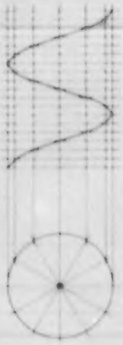
r. ______________________





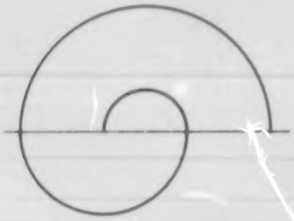
s. ______________________ t. ______________________

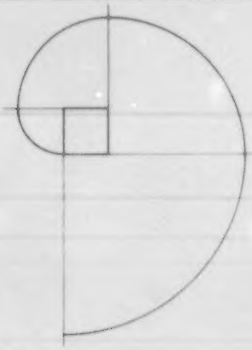




u. ______________________

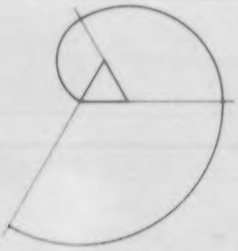
v. ______________________

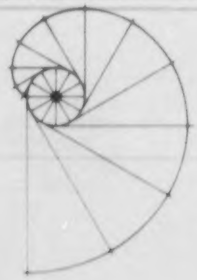




w. ______________________

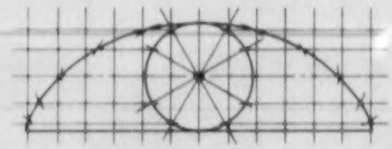
x. ______________________





y. ______________________

z. ______________________



aa. ______________________

8. Match geometric terms on the right with their correct symbols.

_____a. <

_____b. R

_____c. ⊥

_____d. ||

_____e. Φ

_____f. ∠

_____g. ∠s

_____h. >

1. Perpendicular
2. Parallel
3. Angle
4. Angles
5. Less than
6. Greater than
7. Diameter
8. Radius

9. List three elements needed for measuring parts of a circle.

a. ______________________________

b. ______________________________

c. ______________________________

10. List three elements needed for interpreting degrees in a circle.

a. ______________________________

b. ______________________________

c. ______________________________

11. Demonstrate the ability to:

a. Bisect a line and an arc.

b. Bisect an angle.

c. Draw parallel lines.

d. Construct a perpendicular line to a line from a point.

e. Divide a line into equal parts.

f. Draw a line perpendicular through a point on a line.

g. Draw an arc tangent to a straight line and an arc.

h. Draw an arc tangent to two arcs.

i. Construct a triangle with sides given.

j. Construct a right triangle.

k. Construct an equilateral triangle with one side given.

l. Inscribe a hexagon inside a circle.

m. Construct a hexagon with the distance across the flat sides given.

n. Construct a circle through three given points.

o. Construct a pentagon by inscribing.

p. Draw an arc tangent to an acute angle and an obtuse angle.

q. Draw an arc tangent to a right angle.

r. Draw an involute of a circle.

s. Draw an ellipse using the approximate ellipse with compass method.

t. Draw a parabola.

u. Join two points with a parabolic curve.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

GEOMETRIC CONSTRUCTIONS
UNIT II

ANSWERS TO TEST

1. a. 5
   b. 7
   c. 15
   d. 11
   e. 17
   f. 12
   g. 1
   h. 6
   i. 9
   j. 16
   k. 8
   l. 2
   m. 4
   n. 13
   o. 10
   p. 3
   q. 14

2. a. 4
   b. 2
   c. 6
   d. 1
   e. 5
   f. 3

3. a. 1
   b. 4
   c. 5
   d. 3
   e. 2

4. a. 4
   b. 10
   c. 16
   d. 15
   e. 5
   f. 14
   g. 20
   h. 13
   i. 7
   j. 18
   k. 19
   l. 11
   m. 1
   n. 8
   o. 12
   p. 17
   q. 2
   r. 9
   s. 21
   t. 6
   u. 3

5. a. 4
   b. 8
   c. 10
   d. 12
   e. 6
   f. 1
   g. 2
   h. 3
   i. 9
   j. 7
   k. 11
   l. 5

6. a. 5
   b. 2
   c. 4
   d. 6
   e. 1
   f. 3

7. a. Straight angle
   b. Acute angle
   c. Obtuse angle
   d. Isosceles triangle
   e. Scalene triangle
   f. Right triangle
   g. Equilateral triangle
   h. Circle
   i. Sphere
   j. Pentagon
   k. Hexagon
   l. Octagon
   m. Quadrilaterals
      1.) Trapezium
      2.) Trapezoid
      3.) Rectangle
      4.) Square

n. Parallelograms
  1.) Equilateral
    a.) Square
    b.) Rhombus
  2.) Rhomboid
  3.) Rectangle
o. Prism
p. Torus
q. Pyramids
  1.) Right triangular
  2.) Right square
  3.) Pentagonal
r. Ellipse
s. Cylinder
t. Cone
u. Parabola
v. Helix
w. Involute of a line
x. Involute of a square
y. Involute of a triangle
z. Involute of a circle
aa. Cycloid

8.	a.	5	e.	7
	b.	8	f.	3
	c.	1	g.	4
	d.	2	h.	6

9. a. Diameter is measured on a straight line passing through the center point of the circle and extending to the circumference

b. Radius is measured on a straight line from the center of the circle to any point on the circumference; equals one-half the diameter

c. Circumference is measured by multiplying the diameter of the circle by π

10. a. A full circle has 360 degrees, written as 360°
b. Each degree is divided into 60 minutes, written as 60'
c. Each minute is divided into 60 seconds, written as 60"

11. Evaluated to the satisfaction of the instructor

ORTHOGRAPHIC VIEWS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify planes and lines, and construct missing hidden and visible lines, various views, and points, planes, and lines in orthographic views. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to orthographic views with their correct definitions.
2. Distinguish between the types of projection systems.
3. Identify the ISO projection symbols.
4. Arrange in order the steps in visualizing an orthographic projection
5. List the six views possible in orthographic projection.
6. List the three most commonly used views in orthographic projection.
7. Select true statements concerning the steps in selecting correct views of an object.
8. List the basic dimensions of an object.
9. List the most common methods of transferring dimensions.
10. Select the projection of lines in orthographic views.
11. Identify types of planes.
12. Select the correct usage of hidden lines.
13. Select correct line precedence in an orthographic drawing.
14. Identify line thicknesses used in orthographic drawings.
15. State the purpose of runouts.
16. Demonstrate the ability to:
    a. Identify types of planes in orthographic views.
    b. Identify projection of lines in orthographic views.

c. Construct a top view.

d. Construct a front view.

e. Construct a right side view.

f. Construct missing hidden lines.

g. Construct missing visible and hidden lines.

h. Construct circles and arcs using a template.

i. Make a two-view sketch.

j. Make a three-view sketch.

k. Construct a one-view drawing.

l. Construct a two-view drawing.

m. Construct a three-view drawing.

n. Construct a runout.

o. Construct a point in an orthographic view.

p. Construct a line in an orthographic view.

q. Construct a plane in an orthographic view.

17. Construct various orthographic drawings.

ORTHOGRAPHIC VIEWS
UNIT III

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Construct a model in a "Glass box" and discuss orthographic projection.

VII. Use blocks to show various angles and use blocks for sketching.

VIII. Construct blocks, if necessary.

IX. Assignment sheets suggest the use of vellum. Other media may be substituted.

X. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
   - A. Objective sheet
   - B. Information sheet
   - C. Transparency masters
      1. TM 1--Comparison Between First and Third Angle Projection
      2. TM 2--Orthographic Projection
      3. TM 3--Orthographic Projection (Continued)
      4. TM 4--Orthographic Projection (Continued)
      5. TM 5--Orthographic Projection (Continued)
      6. TM 6--Principal Views in Orthographic Projection
      7. TM 7--One-View Drawings
      8. TM 8--Two-View Drawings
      9. TM 9--Three-View Drawings

10. TM 10--Positioning of Views
11. TM 11--Position of Side View
12. TM 12--Methods of Transferring Dimensions
13. TM 13--Visualization of Lines
14. TM 14--Projection of Lines in Orthographics
15. TM 15--Visualization of Planes
16. TM 16--Planes in Orthographic Projection
17. TM 17--Visualization of a Point
18. TM 18--Usage of Hidden Lines
19. TM 19--Line Precedence
20. TM 20--Line Thickness in Orthographic Drawing
21. TM 21--Fillets, Rounds, and Runouts
22. TM 22--Projection of Fillet and Round Edges

D. Assignment sheets

1. Assignment Sheet #1--Identify Types of Planes in Orthographic Views
2. Assignment Sheet #2--Identify Projection of Lines in Orthographic Views
3. Assignment Sheet #3--Construct a Top View
4. Assignment Sheet #4--Construct a Front View
5. Assignment Sheet #5--Construct a Right Side View
6. Assignment Sheet #6--Construct Missing Hidden Lines
7. Assignment Sheet #7--Construct Missing Visible and Hidden Lines
8. Assignment Sheet #8--Construct Circles and Arcs Using a Template
9. Assignment Sheet #9--Make a Two-View Sketch
10. Assignment Sheet #10--Make a Three-View Sketch
11. Assignment Sheet #11--Construct a One-View Drawing
12. Assignment Sheet #12--Construct a Two-View Drawing
13. Assignment Sheet #13--Construct a Three-View Drawing

14. Assignment Sheet #14--Construct a Runout
15. Assignment Sheet #15--Construct a Point in an Orthographic View
16. Assignment Sheet #16--Construct a Line in an Orthographic View
17. Assignment Sheet #17--Construct a Plane in an Orthographic View

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

B. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing.* New York, NY 10022: Macmillan Publishing Co., Inc., 1968.

C. Giesecke, Frederick E., et al. *Technical Drawing.* New York, NY 10022: Macmillan Publishing Co., Inc., 1980.

D. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

ORTHOGRAPHIC VIEWS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Orthographic projection--Method of representing the exact shape of an object in two or more views on planes at right angles to each other

B. First-angle projection--All views are projected onto planes located behind the object

C. Third-angle projection--All views are projected onto planes lying between the object and viewer

D. Projection lines--Lines used to extend from one view to the next view

E. Height--Distance from bottom to top plane

F. Length--Distance from left side to right side plane

G. Depth--Distance from front to back plane

H. Normal plane--True size plane that is parallel to one principal viewing plane and edge view in other two principal planes

I. Foreshortened--To appear shorter to the eye than it actually is

J. Inclined plane--A plane that is foreshortened in two principal viewing planes and edge view in one other principal viewing plane

K. Oblique plane--A plane that is foreshortened in all three principal viewing planes

L. Visualize--To form a mental picture or image

M. Frontal view--Front view

N. Profile view--Left side or right side view

O. Horizontal view--Top view

P. True size--A surface or line that is shown in its actual size

Q. Fold line--A theoretical line between two views where viewing planes fold

(NOTE: This is used as a reference line on drawings.)

R. Line of sight--Direction from which an object is being viewed

INFORMATION SHEET

S. Transfer--Take from one point of view and put in another view

T. Coincide--To match up identically

U. Line precedence--Lines that are more important to show than others

V. Skew (oblique) lines--Nonintersecting lines, not parallel to each other or to the principal views

W. Runout--Intersection of a fillet or round with another surface

X. Fillet--Small rounded inside corner of an object

Y. Round--Small rounded outside corner of an object

(NOTE: Fillets and rounds are normally 1/4" radius or less.)

Z. Line--Straight element that is generated by a moving point and has extension only along the path of the point

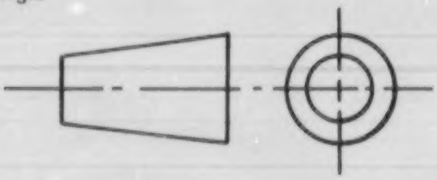
II. Types of projection systems (Transparency 1)

A. First-angle--Used in European and Asian countries

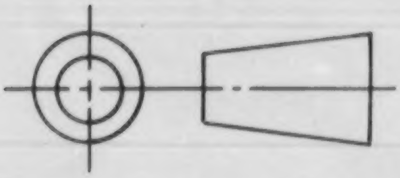
B. Third-angle--Used in the United States, Canada, and other countries

III. ISO (International Standards Organization) projection symbols (Transparency 1)

A. First-angle



B. Third-angle



(NOTE: Location of symbol is in lower right-hand corner of drawing and adjacent to title block.)

INFORMATION SHEET

IV. Steps in visualizing an orthographic projection (Transparencies 2, 3, 4, 5, and 6)

  A. Visualize by looking at the actual object or picture of the object

  B. To obtain views, project the lines of sight to each plane of projection from all points on the object

  C. Rotate all planes until they align with front plane of projection

  D. Visualize the six possible views of the object that are revolved into the same plane as on a drawing surface

  E. Inspect views and determine those needed to adequately represent the object

V. Views possible in orthographic projection (Transparency 4)

  A. Top

  B. Front

  C. Right side

  D. Left side

  E. Bottom

  F. Rear

VI. Most commonly used views in orthographic projection (Transparency 5)

  A. Top

  B. Front

  C. Right side

VII. Steps in selecting correct views of an object (Transparencies 6, 7, 8, 9, 10, and 11)

  A. Select view necessary to best describe contour shape in front view

  B. Select the view that contains the least number of hidden lines

  C. Select alternate position for right side view if drawing area is crowded

  D. Select only needed views necessary to present an understanding of an object

INFORMATION SHEET

E. If there is no other option, select the view that best describes the object

F. Select view positions to avoid crowding of dimensions and notes

VIII. Basic dimensions of an object (Transparencies 2 and 6)

A. Length

B. Height

C. Depth

IX. Most common methods of transferring dimensions (Transparency 12)

A. 45° mitre line

(NOTE: This is used for projecting depth dimensions.)

B. Dividers

C. Scale

X. Projection of lines in orthographic views (Transparencies 13 and 14)

A. Point

B. True length

C. Foreshortened

XI. Types of planes (Transparencies 15 and 16)

A. Normal

B. Inclined

(NOTE: True size is determined by auxiliary views.)

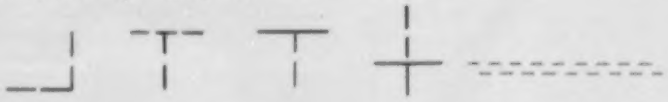
C. Oblique

(NOTE: True size is determined by auxiliary views.)

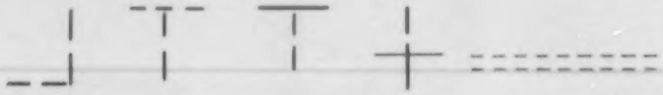
INFORMATION SHEET

XII. Usage of hidden lines (Transparency 18)

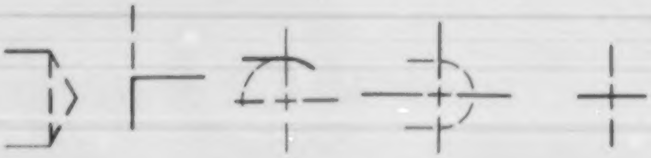
A. Correct



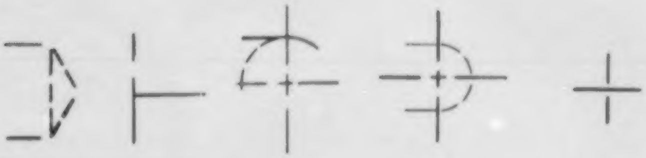
B. Incorrect



C. Correct



D. Incorrect



XIII. Line precedence in an orthographic drawing (Transparency 19)

A. Visible line

B. Hidden line

C. Cutting plane line

D. Center line

XIV. Line thicknesses used in orthographic drawings (Transparency 20)

A. Visible line-- (thick)

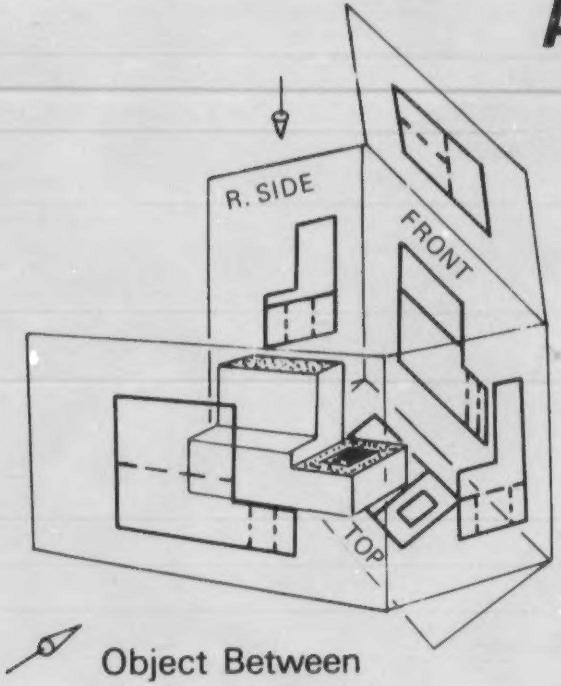
B. Hidden line-- (thin)

C. Center line-- (thin)

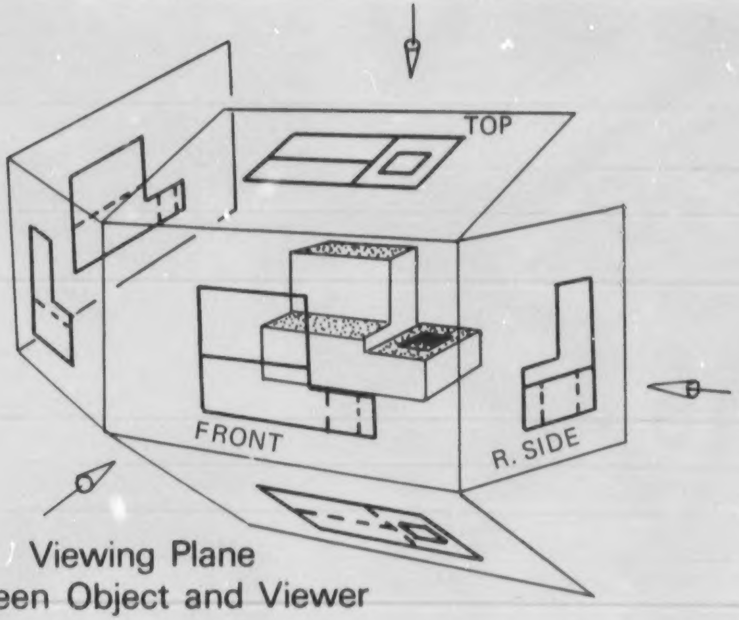
D. Phantom line-- (thin)

XV. Purpose of runouts--Intersection of fillets and rounds are used to eliminate problems in castings (Transparencies 21 and 22)

Comparison Between First and Third Angle Projection

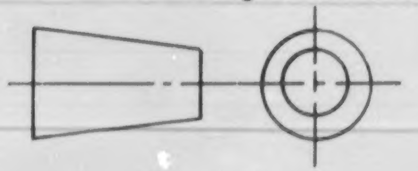

R. SIDE
FRONT
TOP

Object Between
Plane and Viewer


TOP
FRONT
R. SIDE

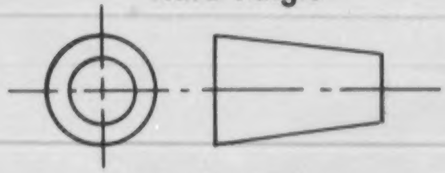
Viewing Plane
Between Object and Viewer

First Angle



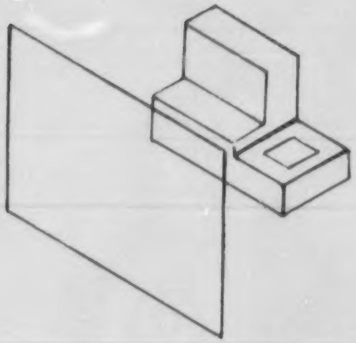
Symbol

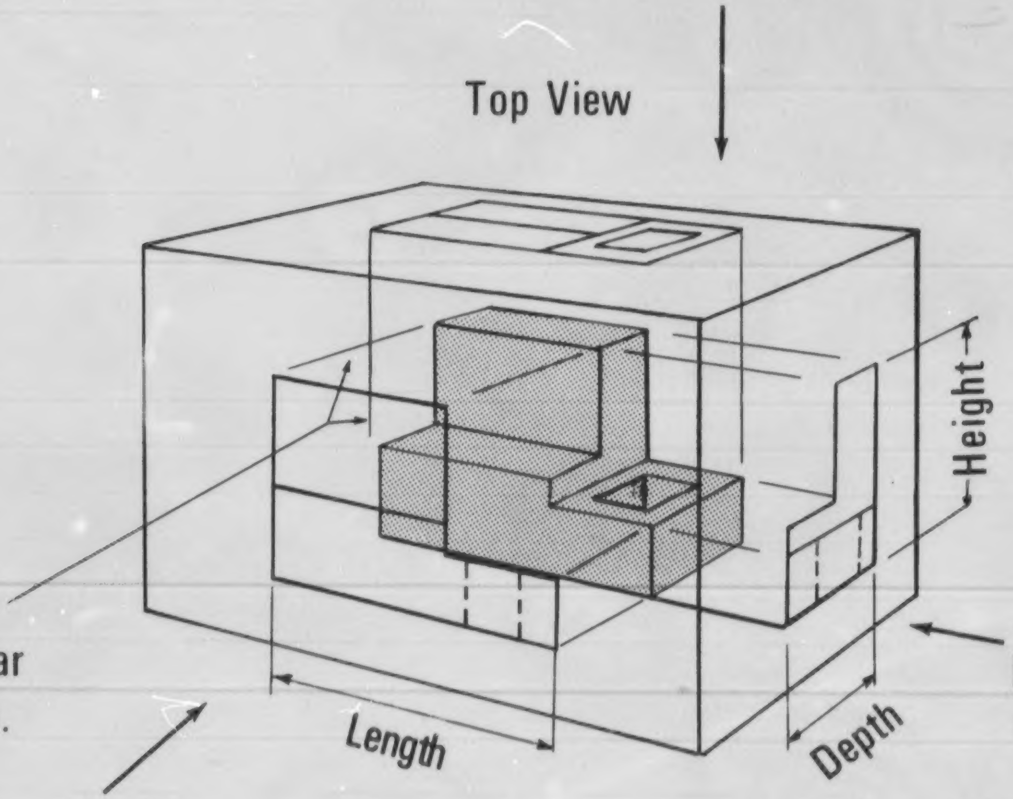
Third Angle



Symbol

Orthographic Projection





Line of Sight

Top View

Height

Line of Sight

Length

Depth

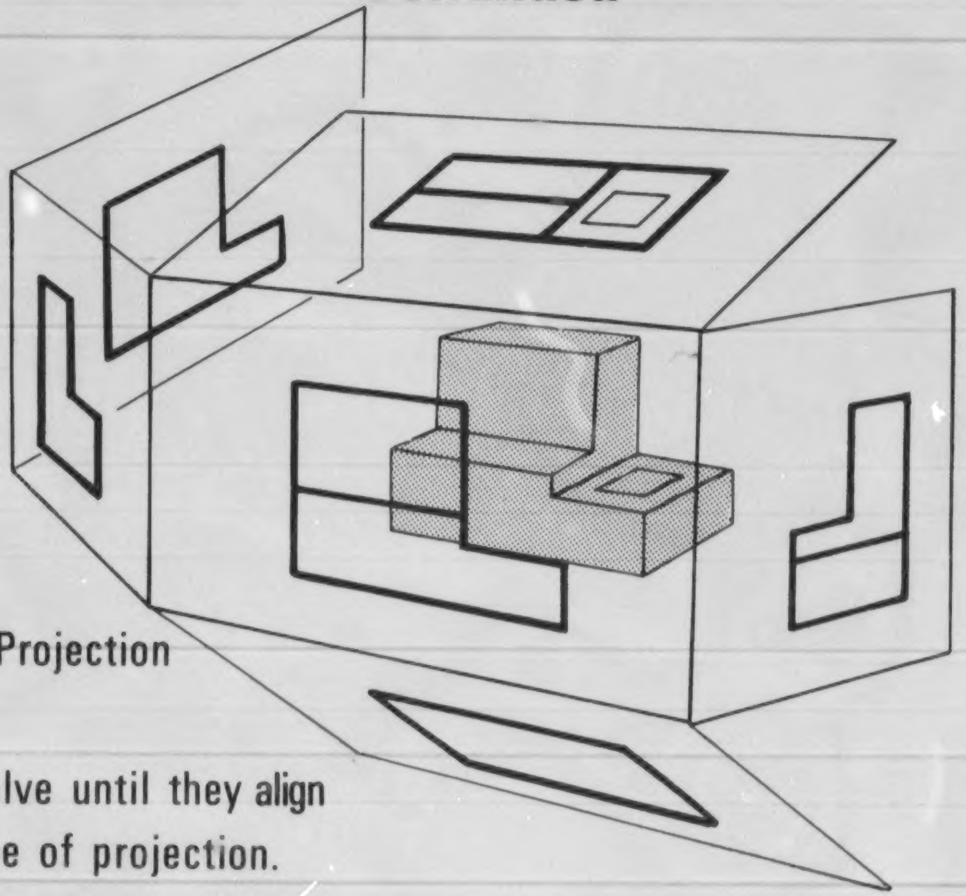
Projectors perpendicular
to planes of projection.

Line of Sight

Front View

R. Side View

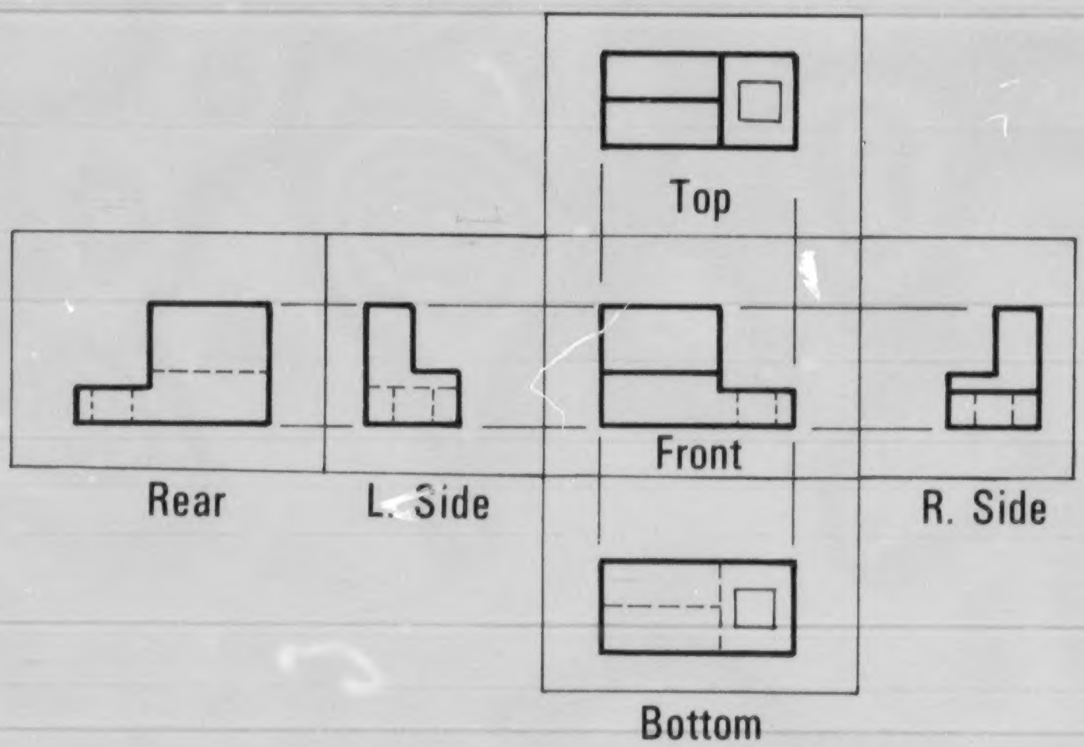
Orthographic Projection Continued



Front Plane of Projection

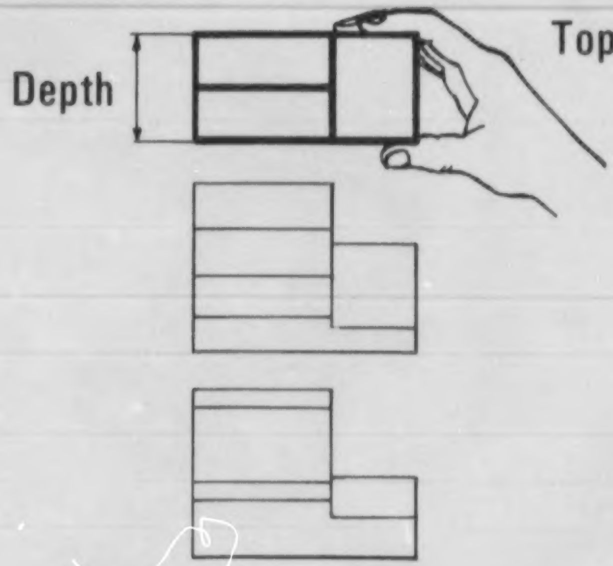
All planes revolve until they align with front plane of projection.

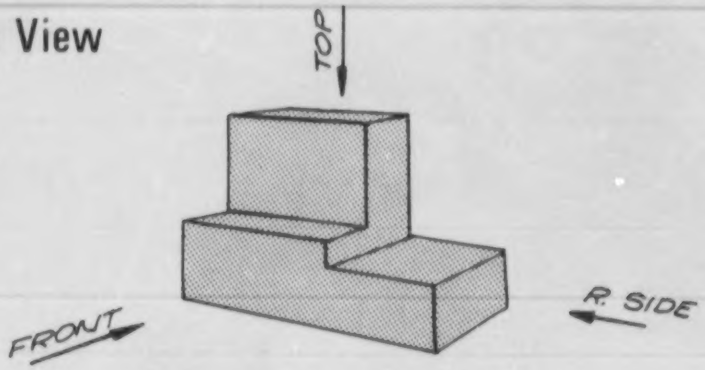
Orthographic Projection Continued


Top
Rear
L. Side
Front
R. Side
Bottom

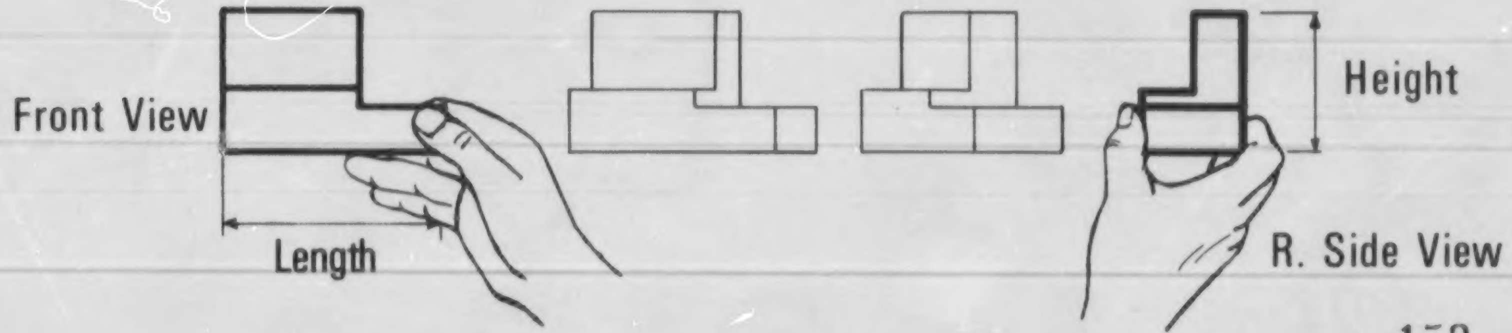
The six planes are layed on a flat plane as on a drawing surface.

Orthographic Projection
Continued


Depth
Top View

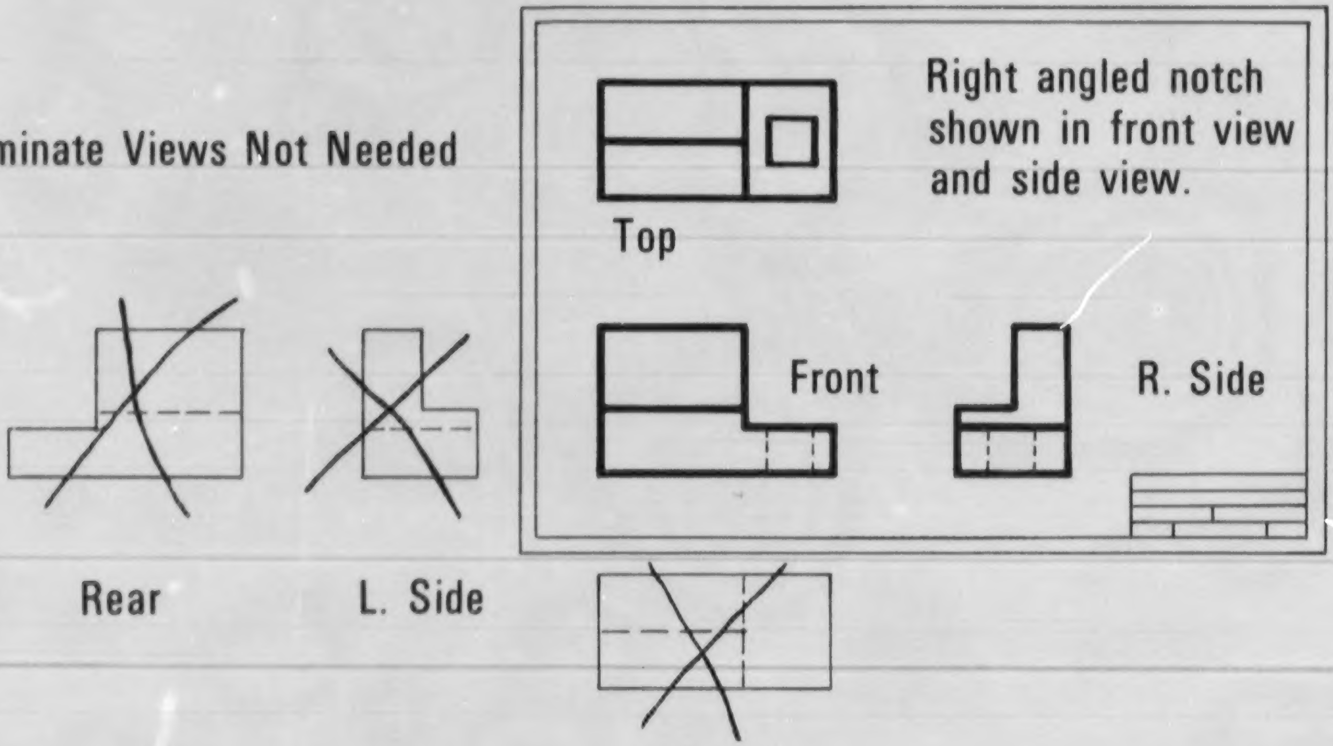

TOP
FRONT
R. SIDE

Draftsman should be able to rotate views in his mind as pictured below.


Front View
Length
Height
R. Side View

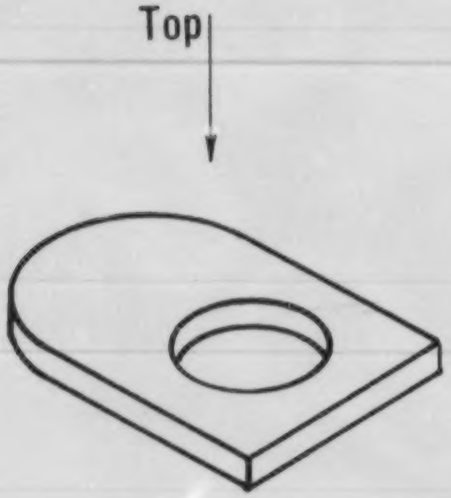
Principal Views in Orthographic Projection

Eliminate Views Not Needed

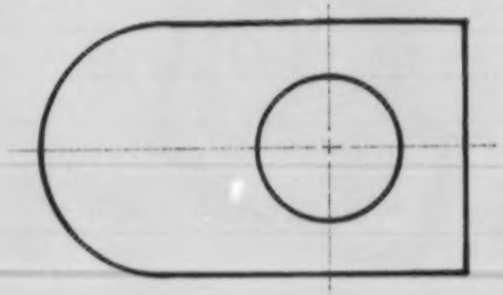

Top
Front
R. Side
Rear
L. Side
Bottom

Right angled notch shown in front view and side view.

One-View Drawings

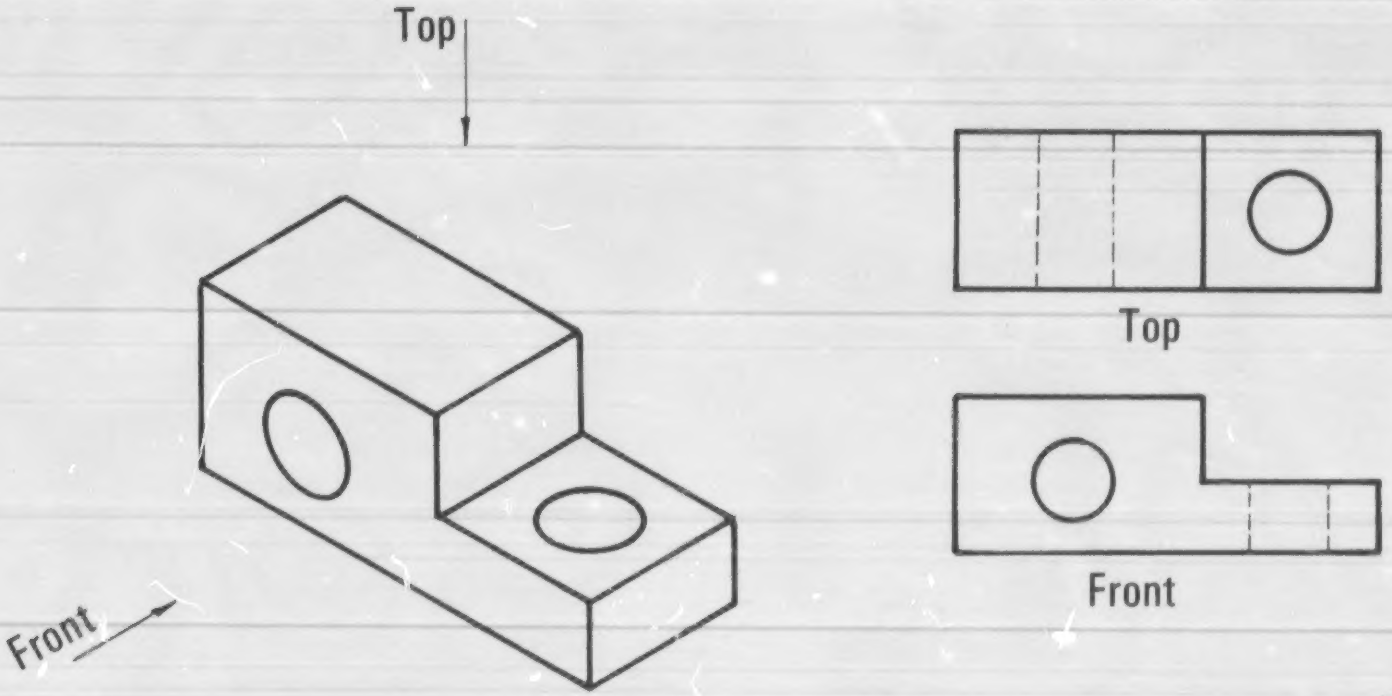


Objects with very little thickness require only one view.



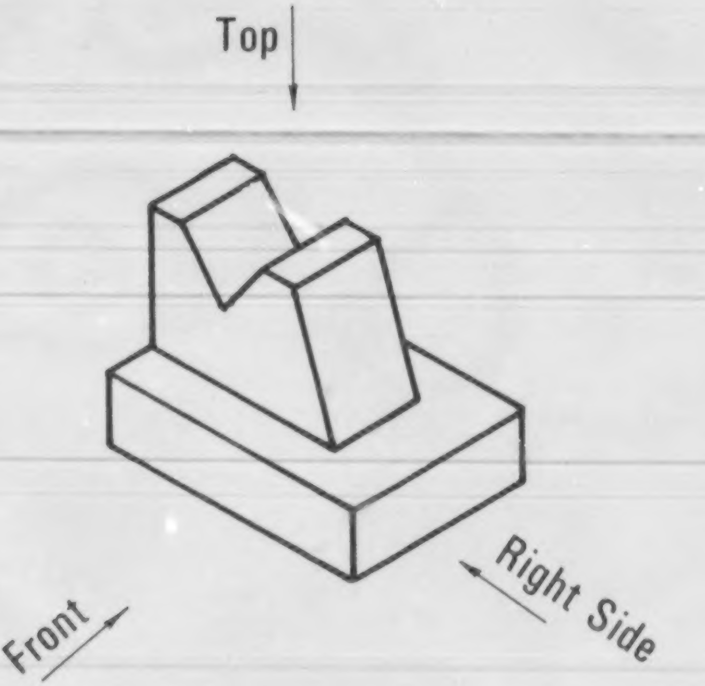
Top View

Two-View Drawings

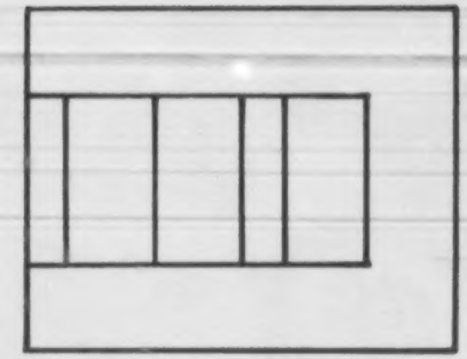

Top
Front
Top
Front

Some objects require only two views.

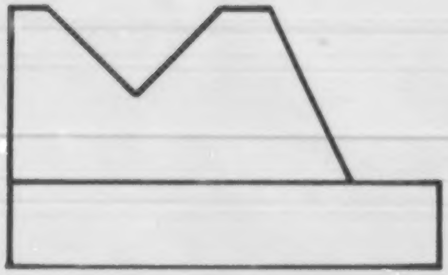
Three-View Drawings


Top
Right Side
Front

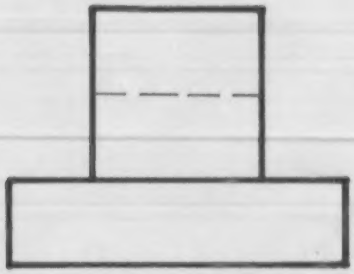
Some objects require three views to describe their shape.



Top View

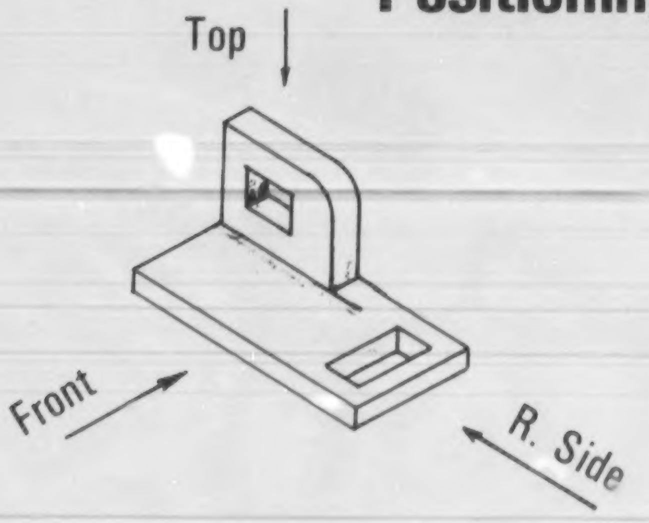


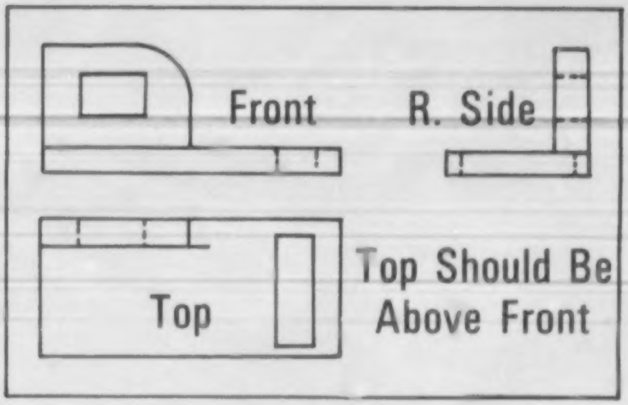
Front



Right Side

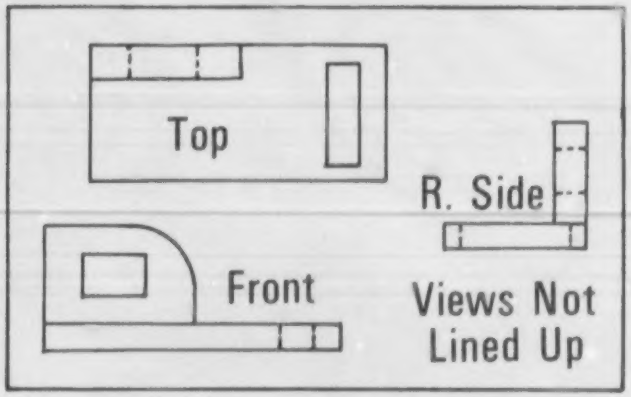
Positioning of Views


Top
Front
R. Side


Front
R. Side
Top

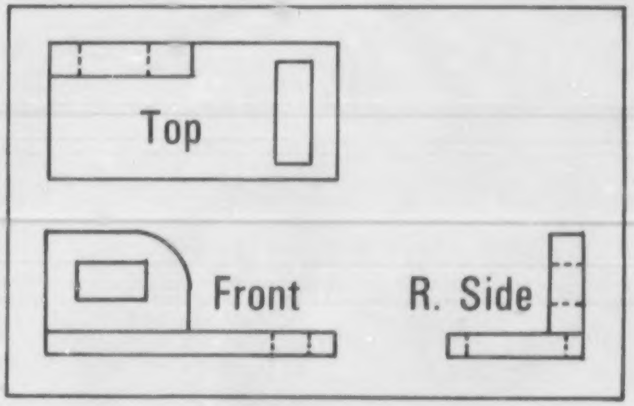
Top Should Be Above Front

INCORRECT


Top
R. Side
Front

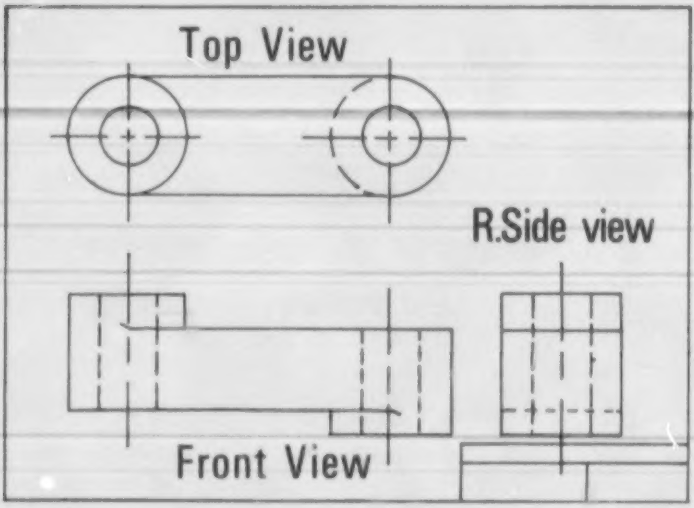
Views Not Lined Up

INCORRECT


Top
Front
R. Side

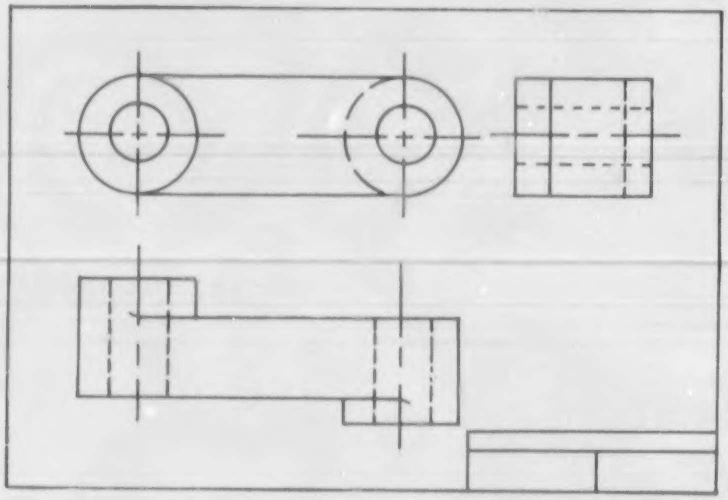
CORRECT

Position of Side View


Top View
R.Side view
Front View

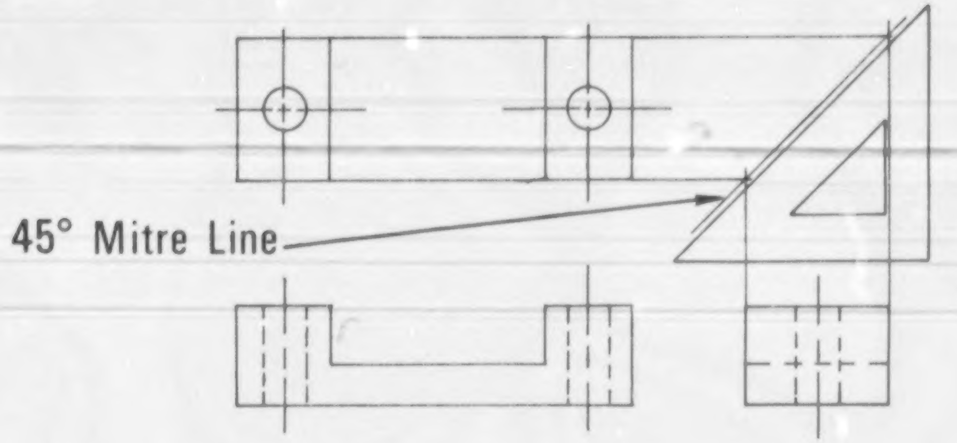
NORMAL LOCATION

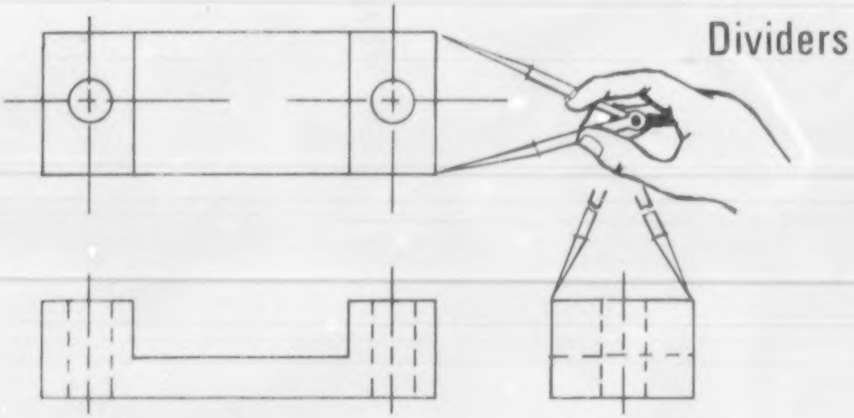
- Shape of object determines best location for side view.
- R. Side view can be projected off the front view or the top view.
- Space limitation requires alternate location.

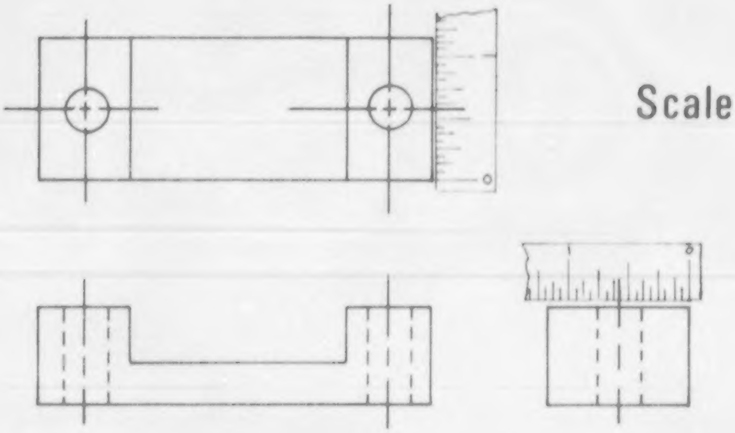


ALTERNATE LOCATION

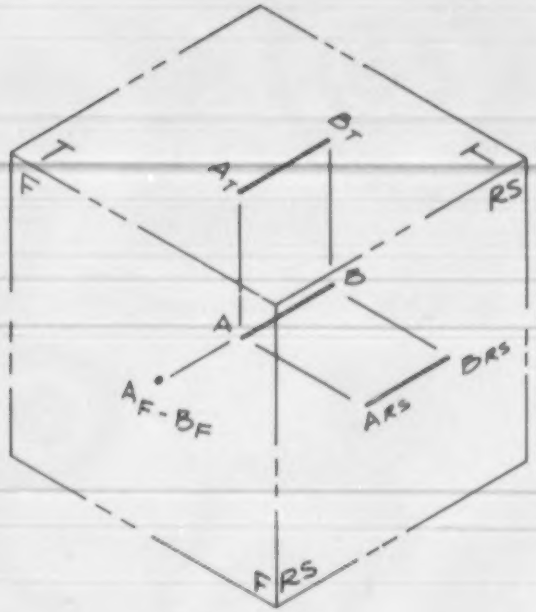
Methods of Transferring Dimensions


45° Mitre Line

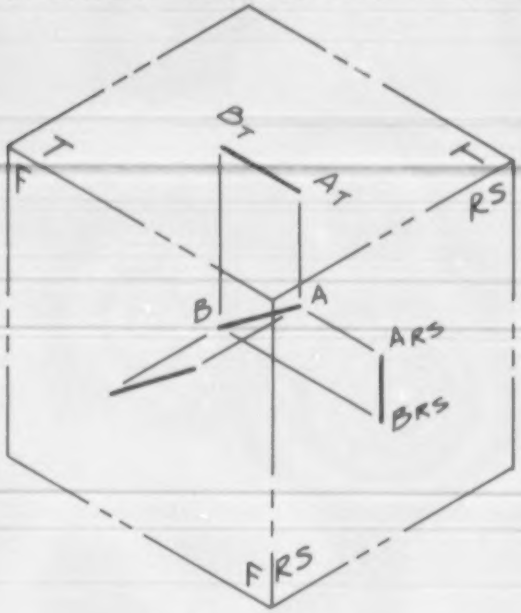




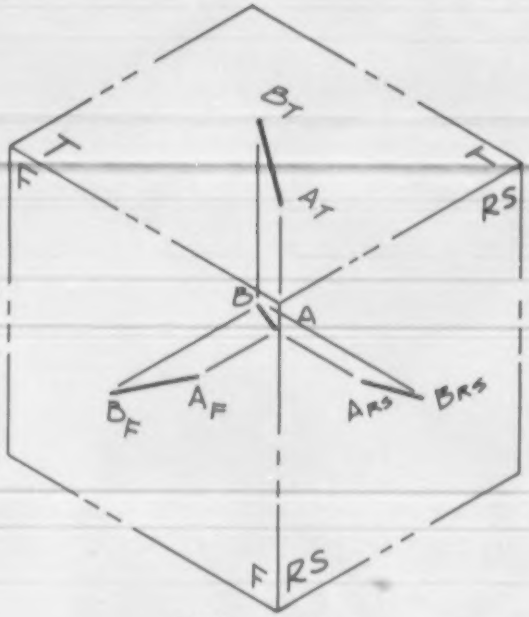
Visualization of Lines


T
F
B_T
A_T
T
RS
B
A
$A_F - B_F$
B_{RS}
A_{RS}
F
RS

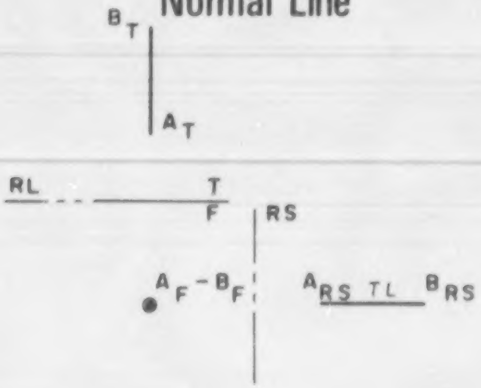
Normal Line

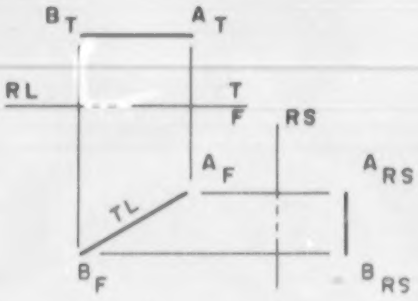

T
F
B_T
A_T
T
RS
B
A
A_{RS}
B_{RS}
F
RS

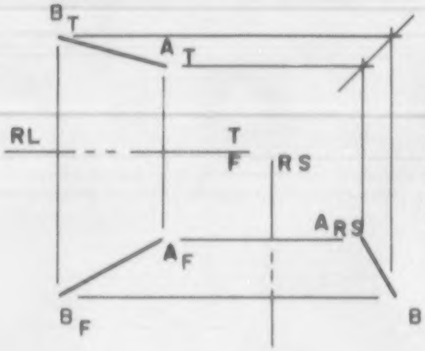
Inclined Line


T
F
B_T
A_T
T
RS
B
A
B_F
A_F
A_{RS}
B_{RS}
F
RS

Oblique Line

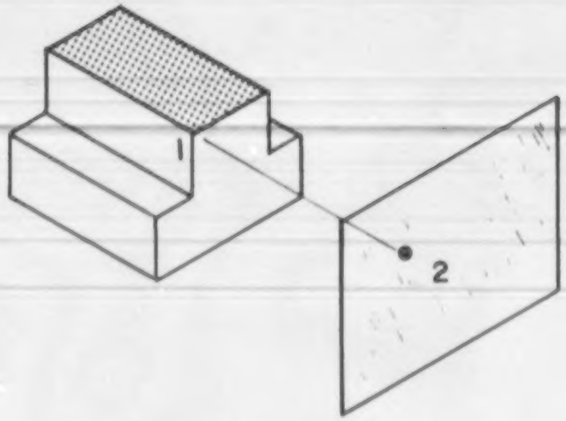

B_T
A_T
RL
T
F
RS
$A_F - B_F$
A_{RS} TL B_{RS}


B_T
A_T
RL
T
F
RS
A_F
A_{RS}
TL
B_F
B_{RS}

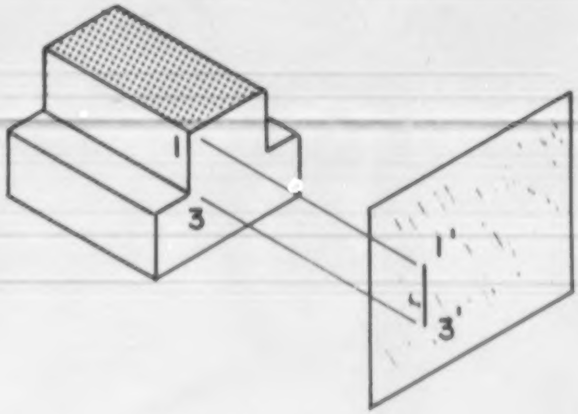

B_T
A_T
RL
T
F
RS
A_{RS}
A_F
B_F
B_{RS}

All
Three
Views
Fore-
shortened

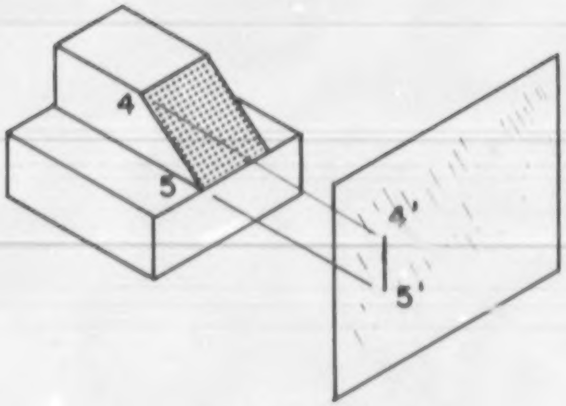
Projection of Lines in Orthographics



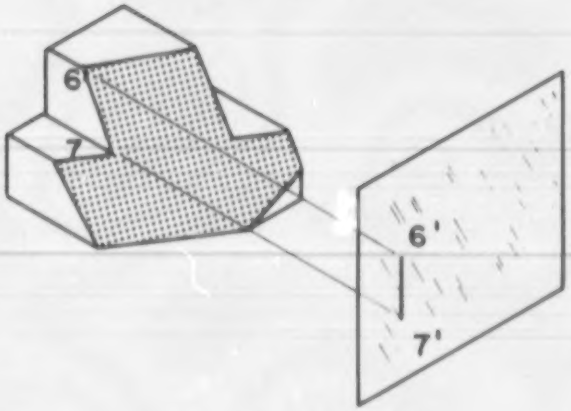
Point



True Length Line

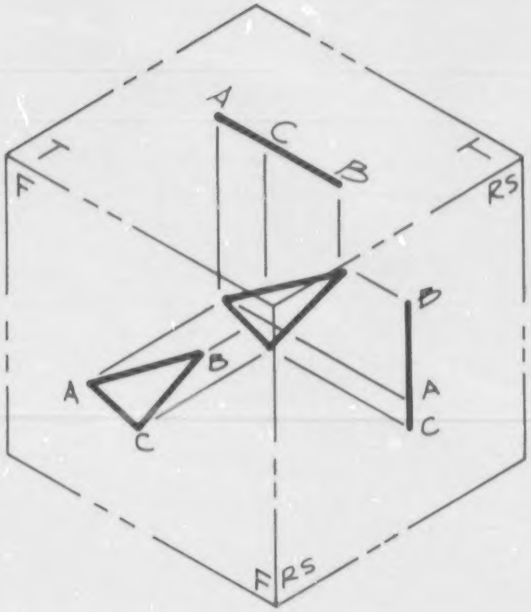


Foreshortened

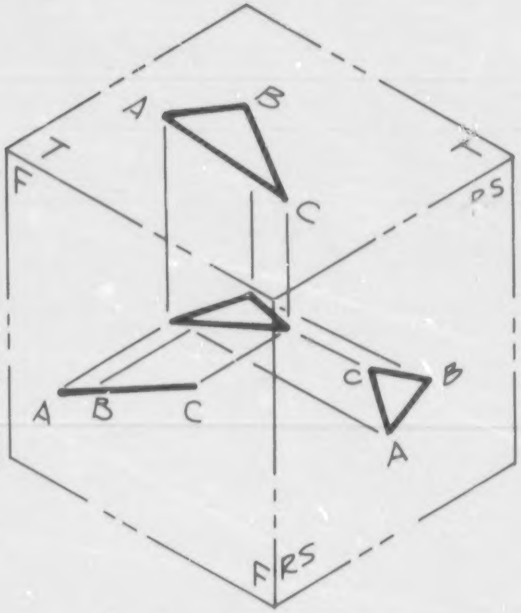


Foreshortened

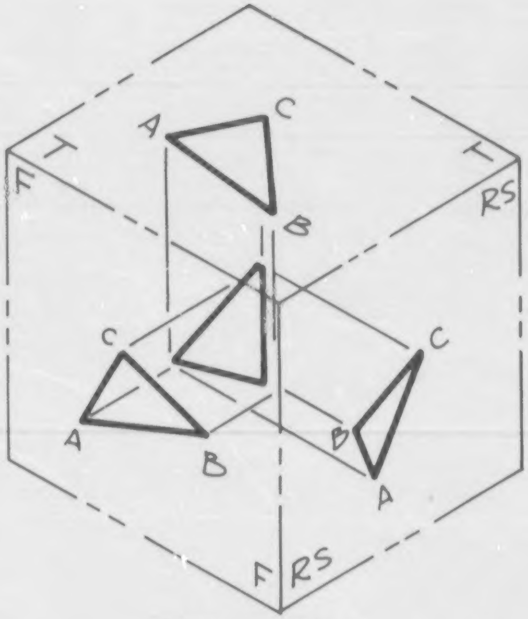
Visualization of Planes


T
F
A
C
B
T
RS
B
A
C
A
C
B
F
RS

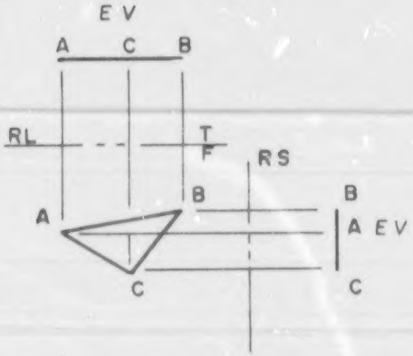
Normal plane

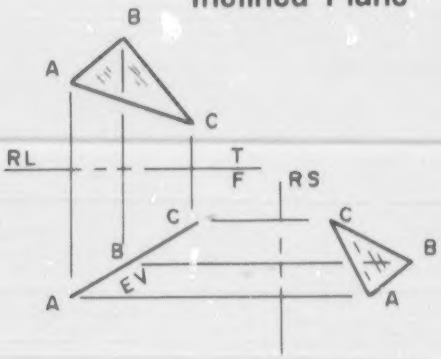

T
F
A
B
C
T
RS
A
B
C
C
B
A
F
RS

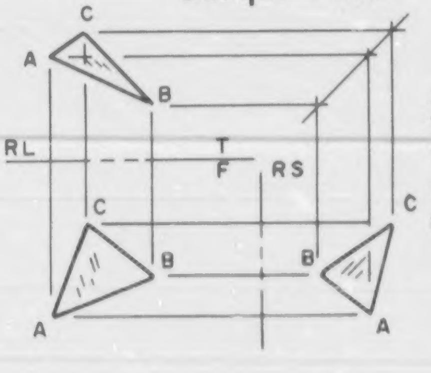
Inclined Plane


T
F
A
C
B
T
RS
C
A
B
C
B
A
F
RS

Oblique Plane

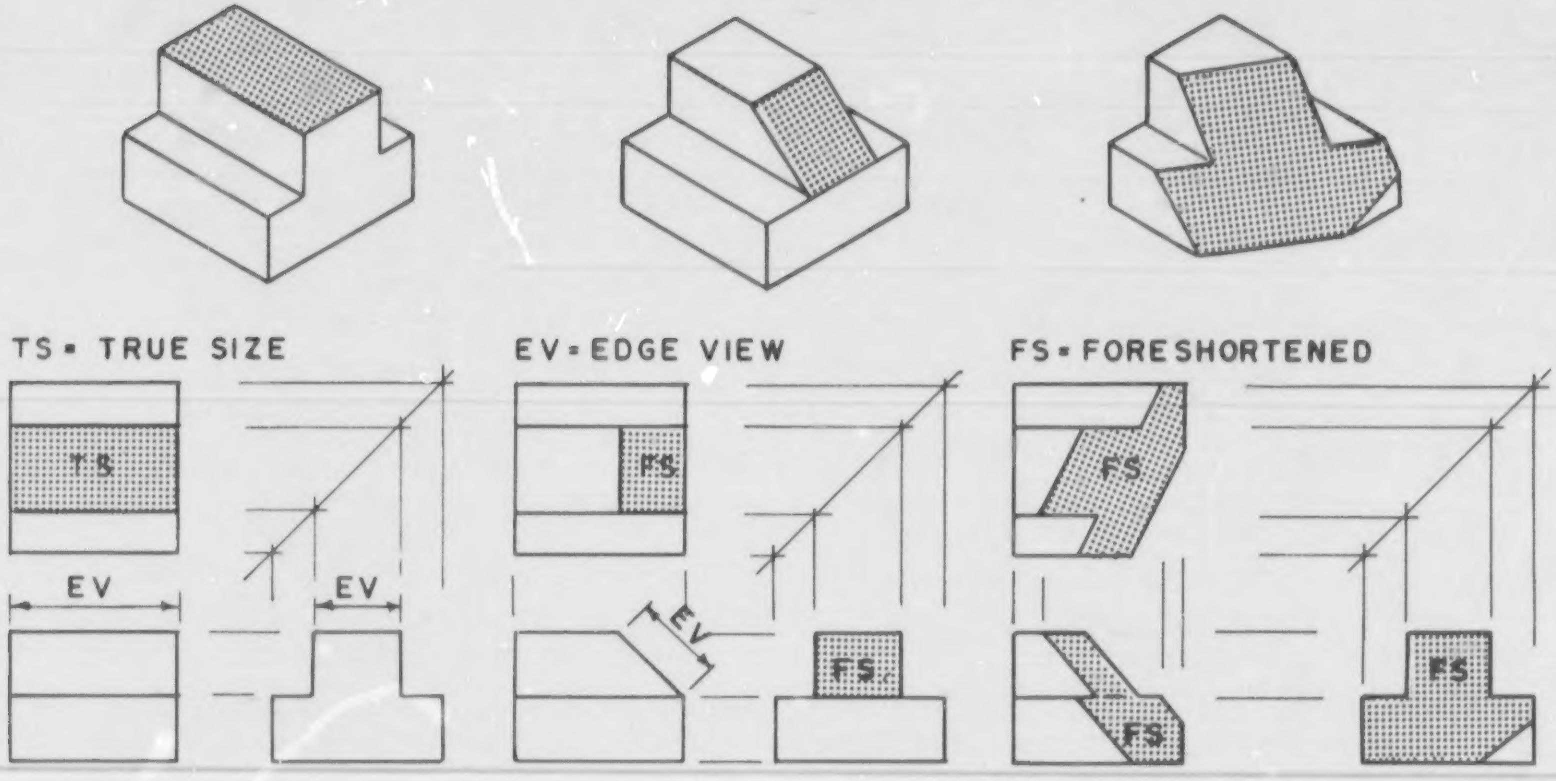

E V
A
C
B
RL
T
F
RS
B
A
C
B
A EV
C


B
A
C
RL
T
F
RS
C
C
B
EV
A
B
A


C
A
B
RL
T
F
RS
C
C
B
B
A
A

All
Three
Views
Fore-
shortened

Planes in Orthographic Projection

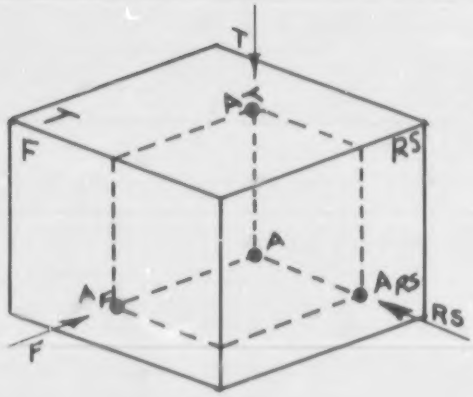

TS = TRUE SIZE
TS
EV
EV
EV = EDGE VIEW
FS
EV
FS
FS = FORESHORTENED
FS
FS
FS

Normal

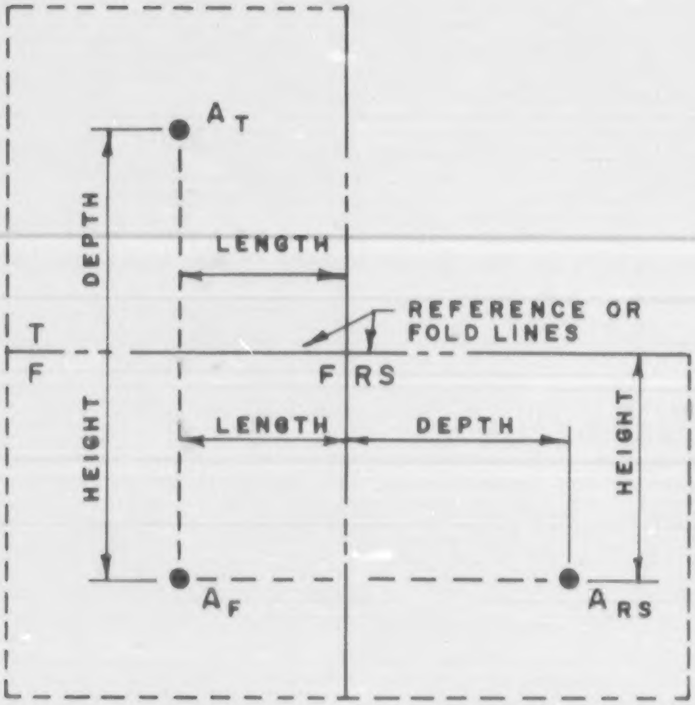
Inclined

Oblique

Visualization of a Point

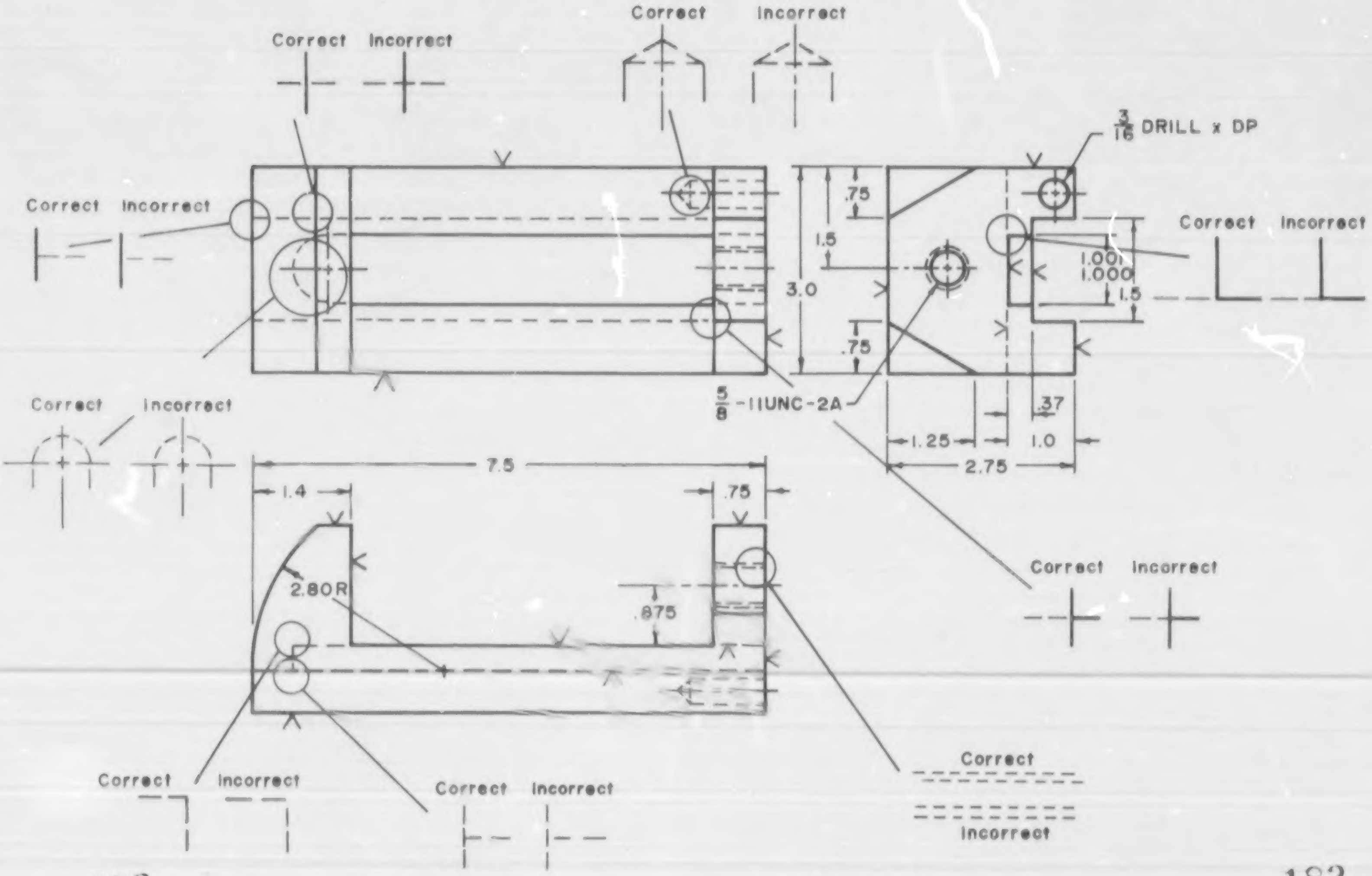

T
T
F
RS
A_T
A
A_F
A_{RS}
F
RS

Space Picture

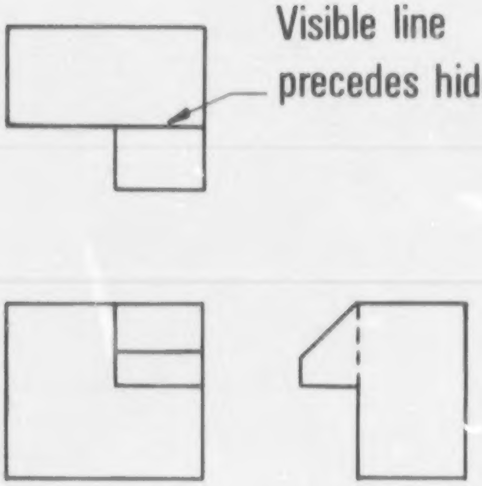

A_T
DEPTH
LENGTH
REFERENCE OR FOLD LINES
T
F
F
RS
HEIGHT
LENGTH
DEPTH
HEIGHT
A_F
A_{RS}

Orthographic View

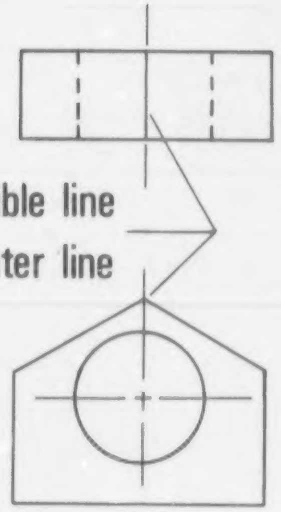
Usage of Hidden Lines


Correct
Incorrect
Correct
Incorrect
3/16 DRILL x DP
Correct
Incorrect
.75
1.5
3.0
.75
1.001
1.000
1.5
Correct
Incorrect
Correct
Incorrect
5/8 -11UNC-2A
.37
1.25
1.0
2.75
7.5
1.4
.75
2.80R
.875
Correct
Incorrect
Correct
Incorrect
Correct
Incorrect
Correct
Incorrect

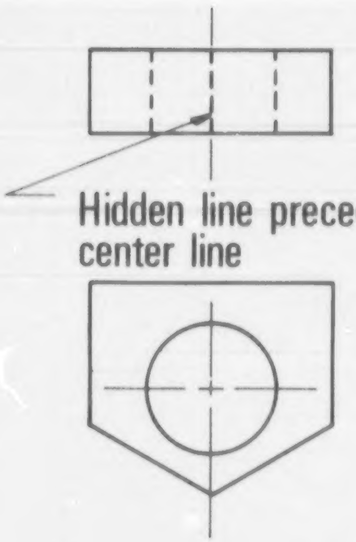
Line Precedence



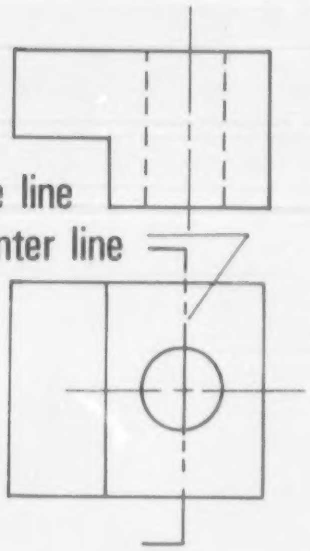
Visible line precedes hidden line



Visible line precedes center line

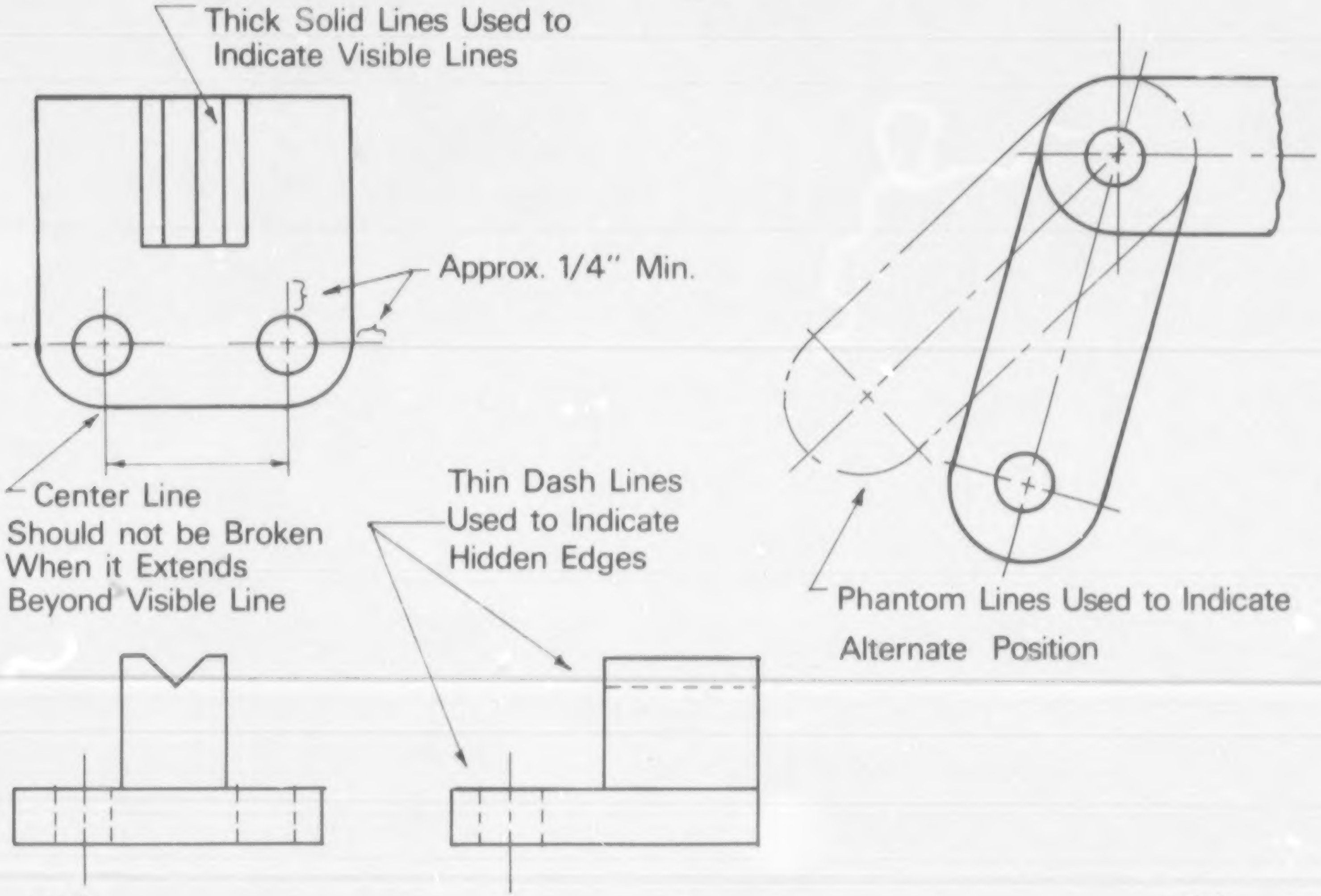


Hidden line precedes center line



Cutting plane line precedes center line

Line Thickness in Orthographic Drawing



Thick Solid Lines Used to Indicate Visible Lines

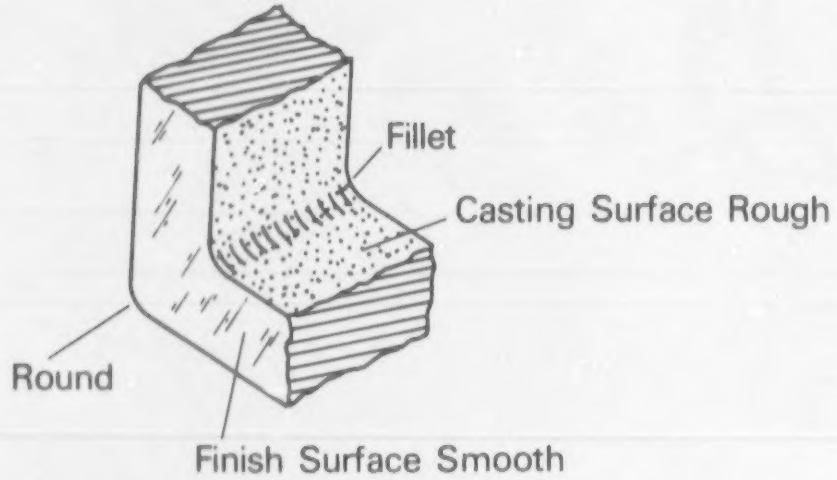
Approx. 1/4" Min.

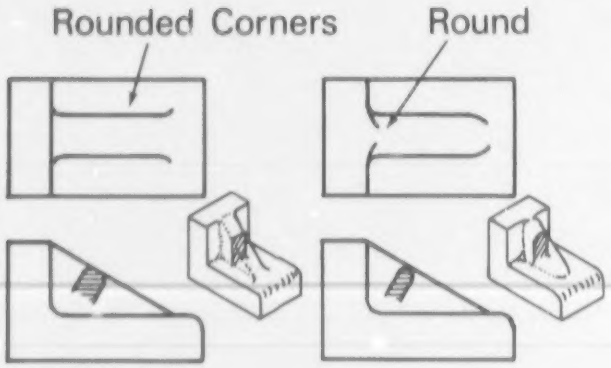
Center Line Should not be Broken When it Extends Beyond Visible Line

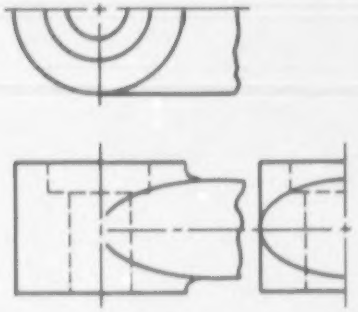
Thin Dash Lines Used to Indicate Hidden Edges

Phantom Lines Used to Indicate Alternate Position

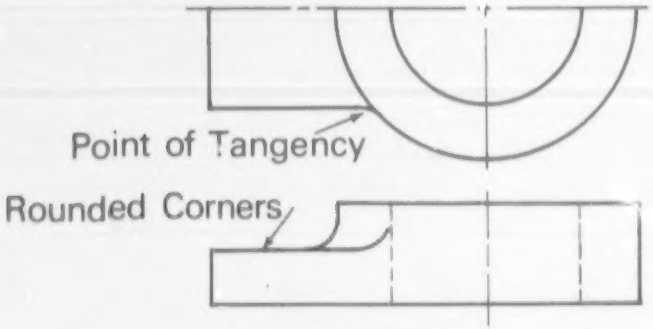
Fillets, Rounds, and Runouts


Fillet
Casting Surface Rough
Round
Finish Surface Smooth


Rounded Corners
Round

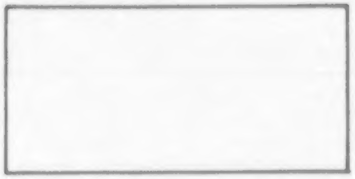


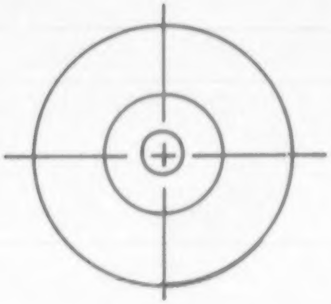
Runout Intersection
Between a Cylinder
and an Elliptical Part

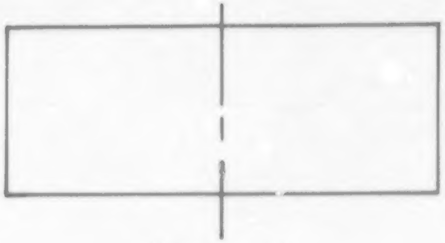

Point of Tangency
Rounded Corners

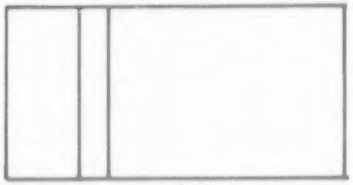
Runout Intersection
Between a Cylinder
and Rounded Part

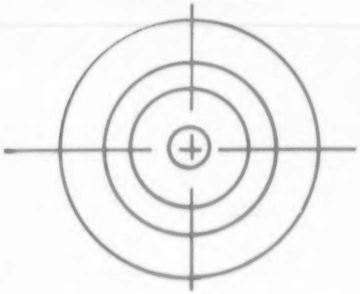
Projection of Fillet and Round Edges

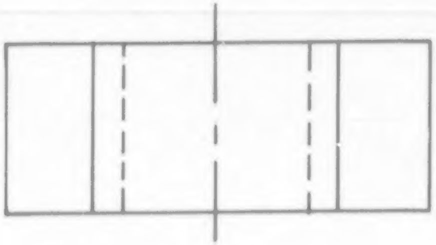

Incorrect

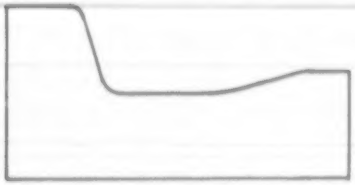

Incorrect

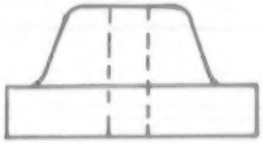

Incorrect

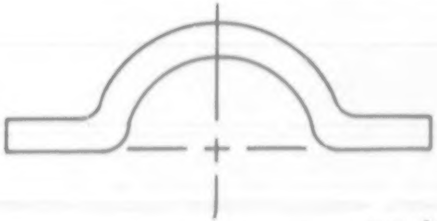

Correct


Correct


Correct





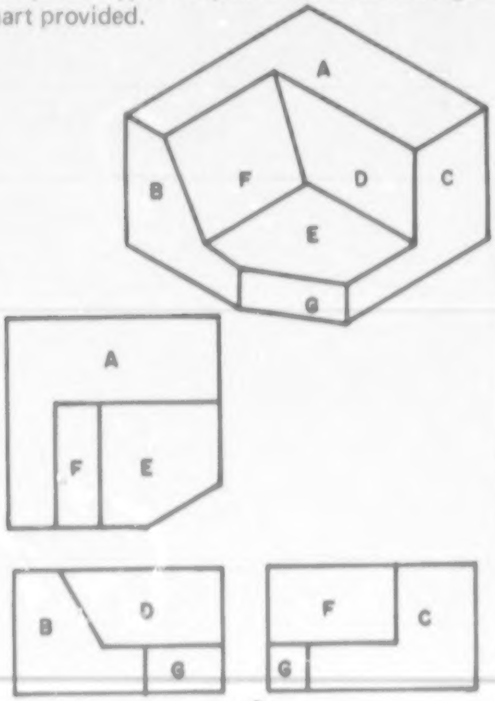


ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #1--IDENTIFY TYPES OF PLANES IN ORTHOGRAPHIC VIEWS

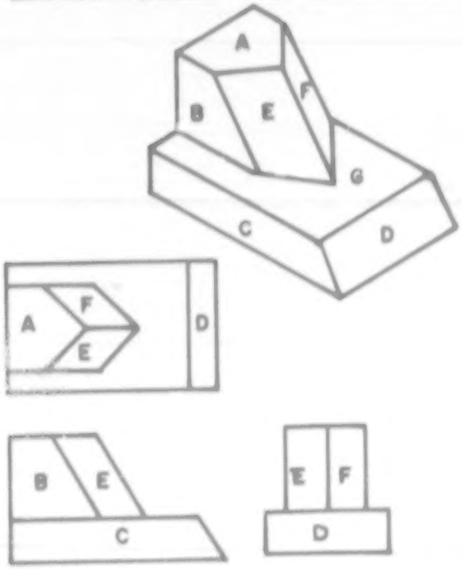
Directions: Identify the types of planes in the drawings by writing normal, inclined, or oblique in the chart provided.

Problem A:


A
B
F
D
C
E
G
A
F
E
B
D
G
F
C
G

PLANE	TYPE
A	
B	
C	
D	
E	
F	
G	

Problem B:

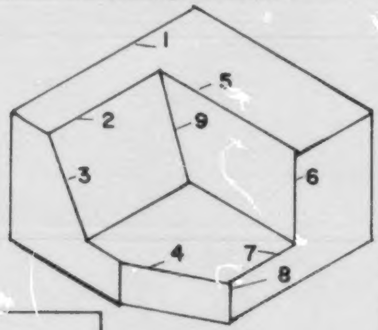

A
B
E
F
G
C
D
A
F
E
D
B
E
C
E
F
D

PLANE	TYPE
A	
B	
C	
D	
E	
F	
G	

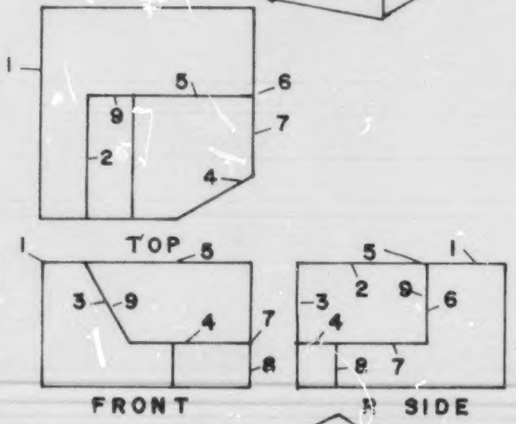
ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #2--IDENTIFY PROJECTION OF LINES IN ORTHOGRAPHIC VIEWS

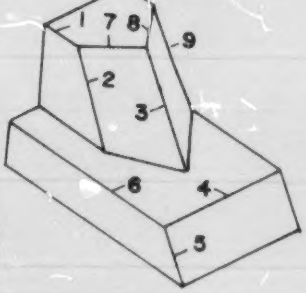
Directions: Identify correct projection of lines in the drawings by writing point, true length, or foreshortened in the chart provided.



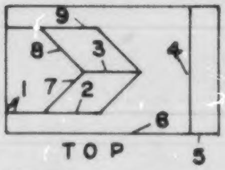
Problem A:

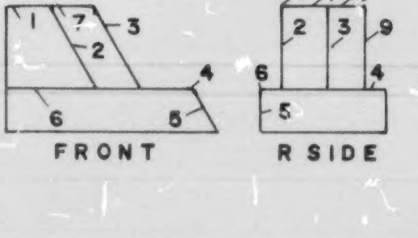

1
5
6
9
7
2
4
TOP
1
5
3
9
4
7
8
FRONT
5
1
2
9
6
3
4
8
7
R SIDE

LINE	TOP	FRONT	R SIDE
1			
2			
3			
4			
5			
6			
7			
8			
9			



Problem B:


9
8
3
4
1
7
2
6
TOP
5


1
7
3
2
4
6
5
FRONT
1
7
8
2
3
9
6
4
5
R SIDE

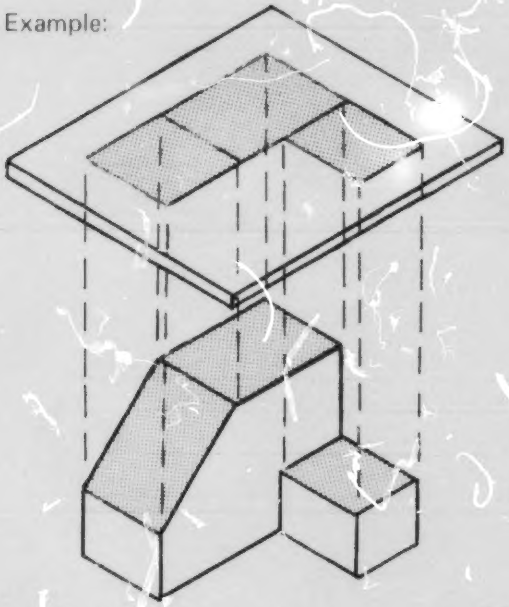
LINE	TOP	FRONT	R SIDE
1			
2			
3			
4			
5			
6			
7			
8			
9			

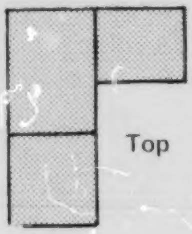
ORTHOGRAPHIC VIEWS
UNIT III

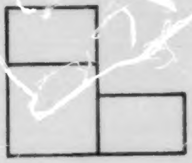
ASSIGNMENT SHEET #3--CONSTRUCT A TOP VIEW

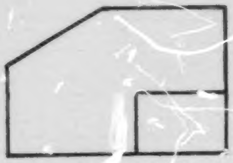
Premise: The top view is first viewed on an imaginary plane, and then drawn in its correct position using mitre method of transferring dimensions.

Example:





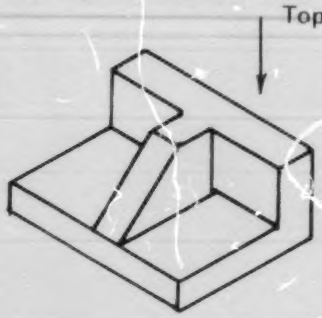


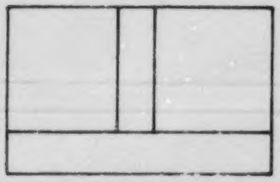


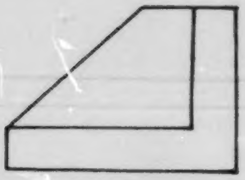
Directions: Align views with drafting machine and tape down. Construct top views of the following objects. Do not show hidden lines.

Problem A:

Top Here

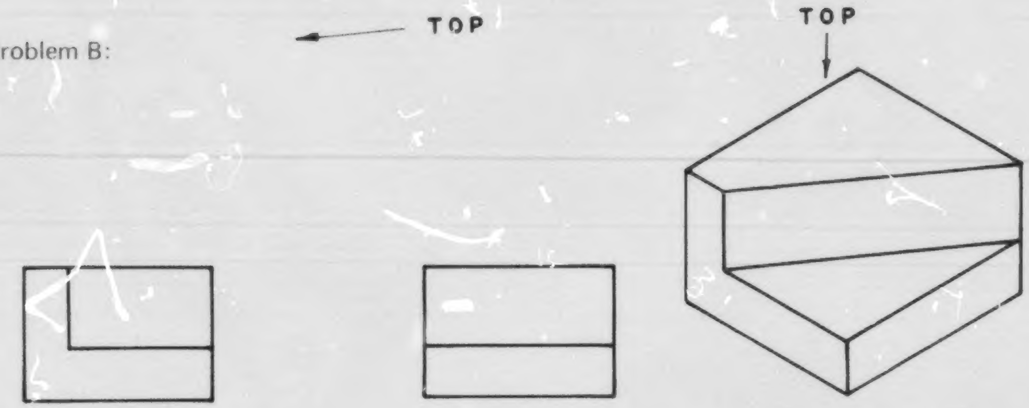




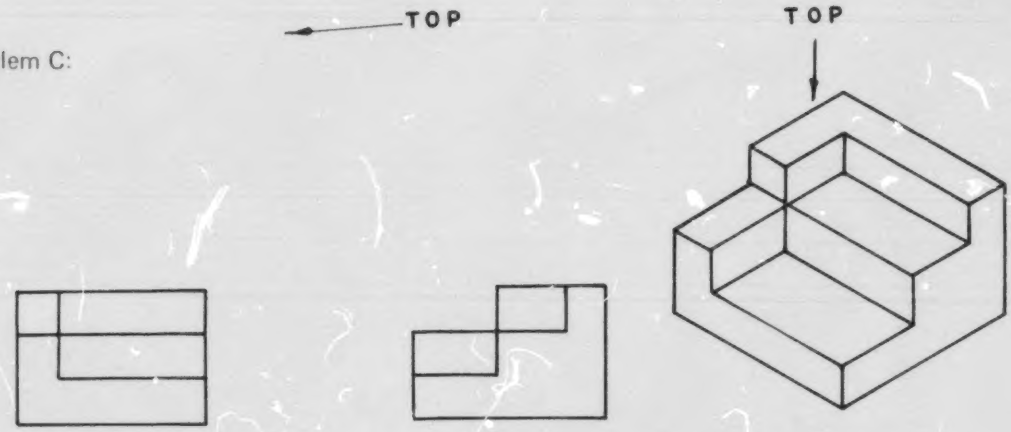


ASSiGNMENT SHEET #3

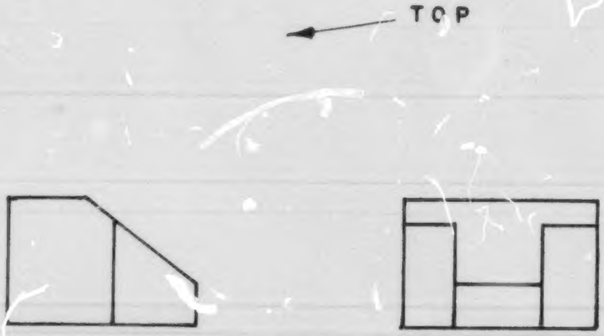
Problem B:



Problem C:



Problem D:

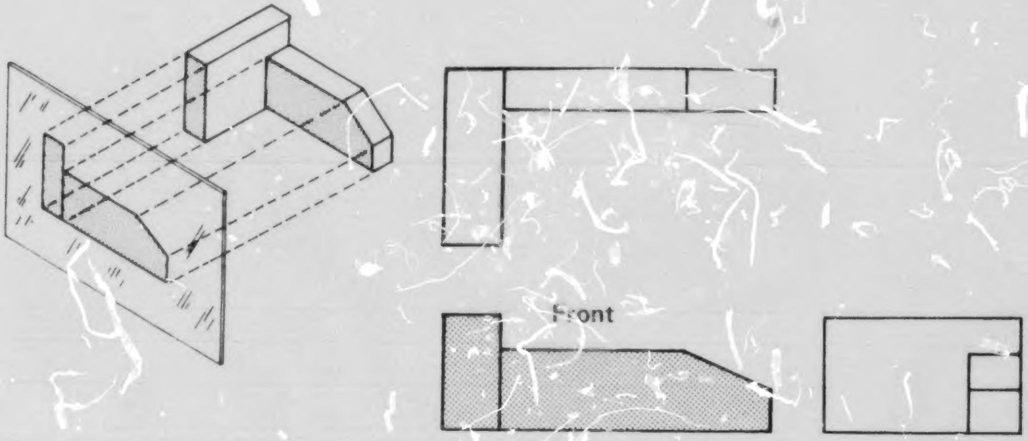


ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #4--CONSTRUCT A FRONT VIEW

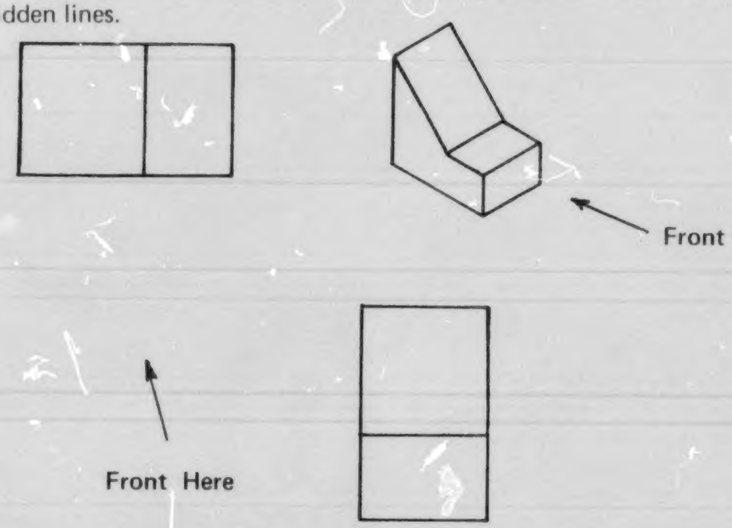
Premise: The front view is first viewed on an imaginary plane, and then drawn in its correct position.

Example:



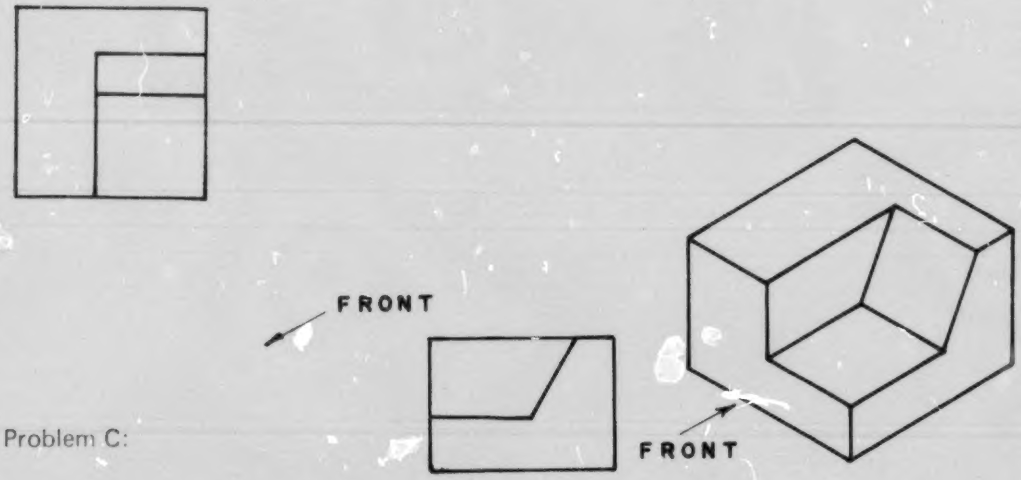
Directions: Construct the front views of the following objects. Align, tape down, and do not show hidden lines.

Problem A:

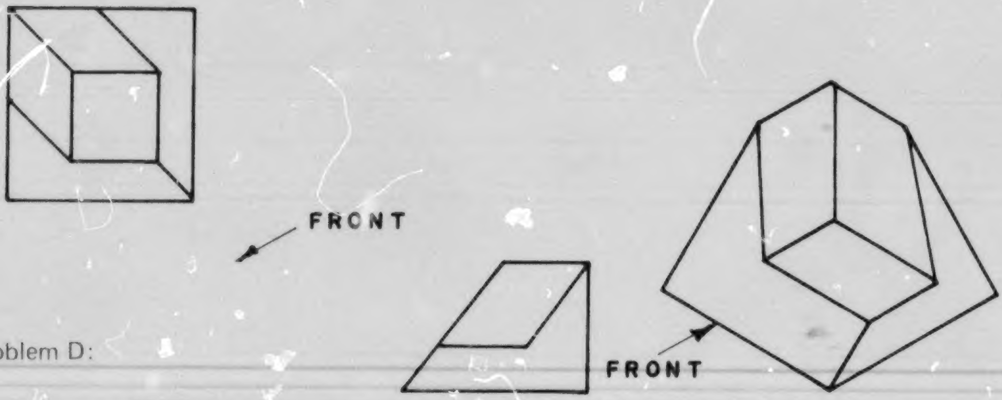


ASSIGNMENT SHEET #4

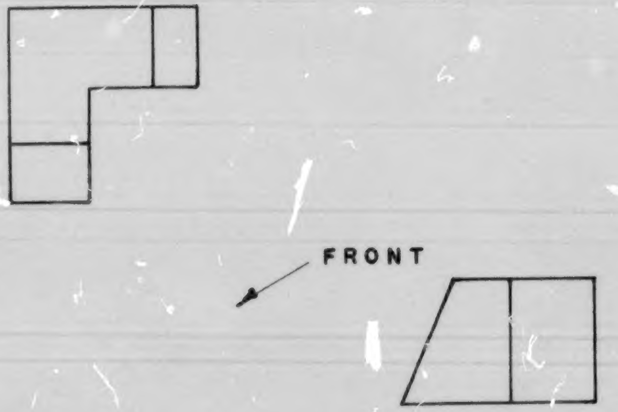
Problem B:


FRONT
FRONT

Problem C:


FRONT
FRONT

Problem D:

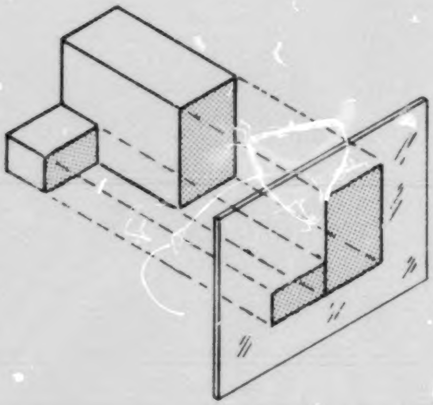


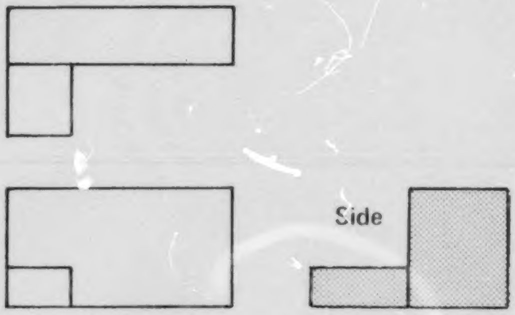
ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #5--CONSTRUCT A RIGHT SIDE VIEW

Premise: The end view is first viewed on an imaginary plane, and then drawn in its correct position (right or left).

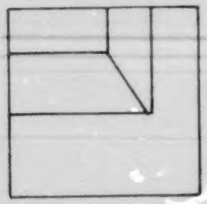
Example:

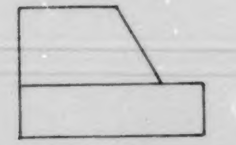


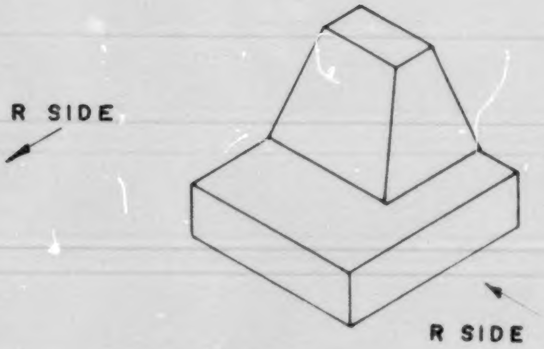


Directions: Align views with drafting machine and tape down. Construct the right side view in the space provided.

Problem A:

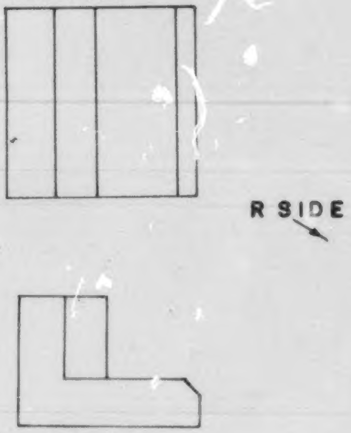


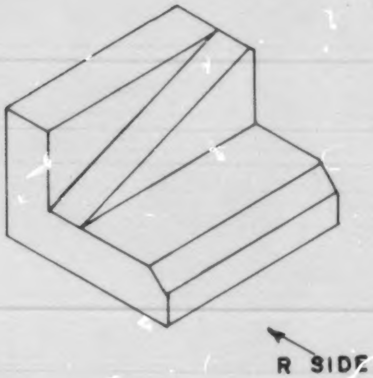




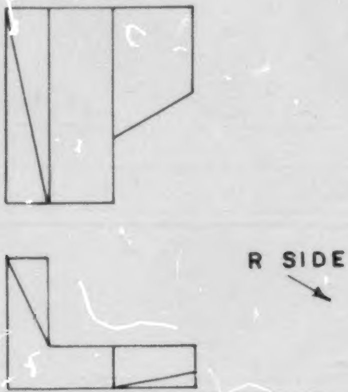
ASSIGNMENT SHEET #5

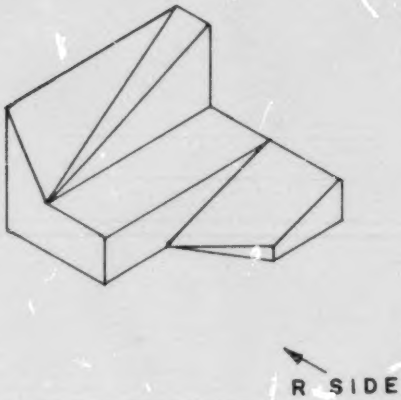
Problem B:



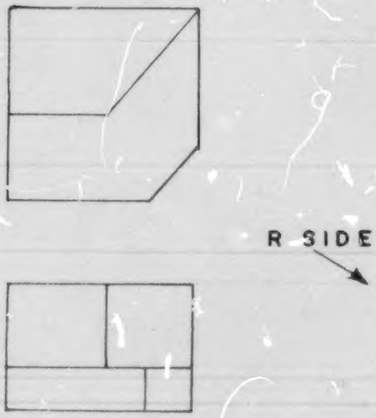


Problem C:





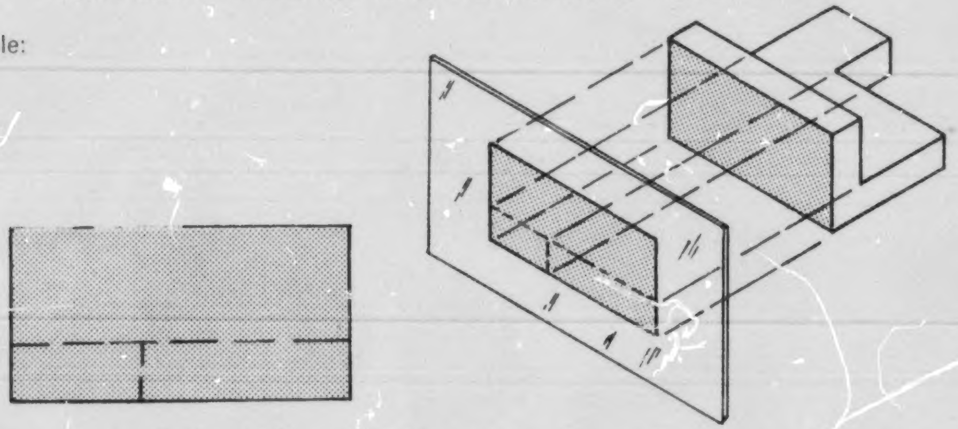
Problem D:



ORTHOGRAPHIC VIEWS
UNIT III

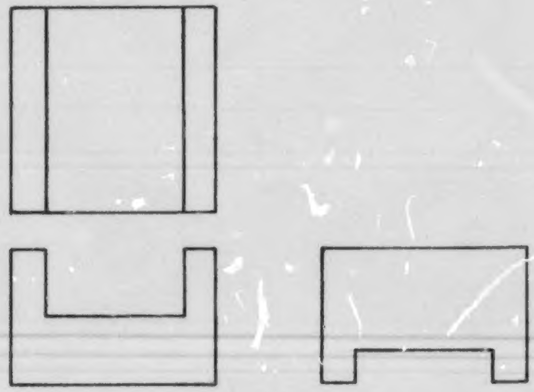
ASSIGNMENT SHEET #6--CONSTRUCT MISSING HIDDEN LINES

Example:

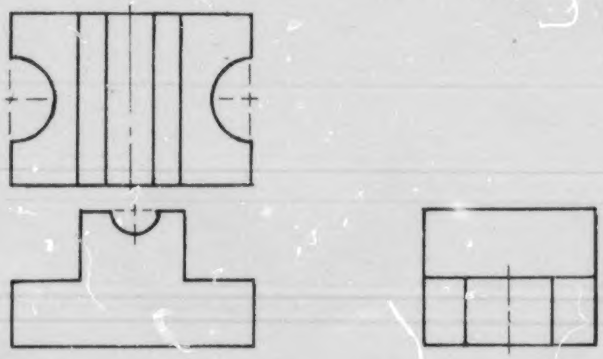


Directions: Construct the missing hidden lines in the views below. Align and tape down.

Problem A:

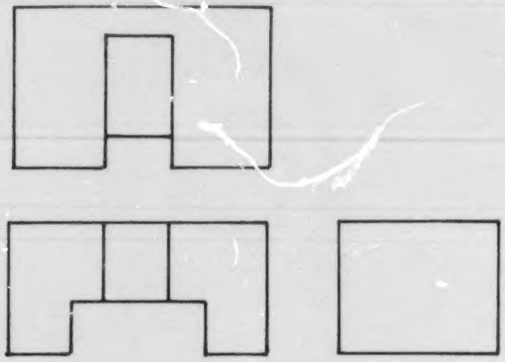


Problem B:

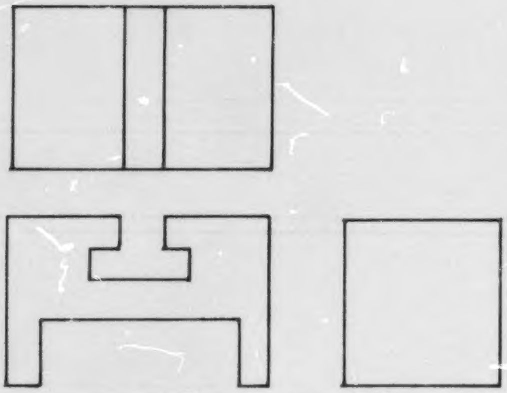


ASSIGNMENT SHEET #6

Problem C:



Problem D:

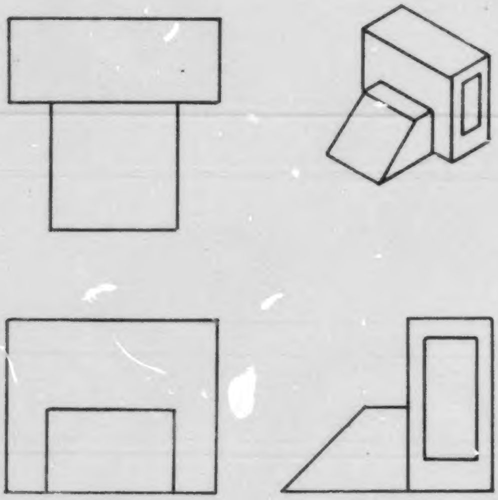


ORTHOGRAPHIC VIEWS
UNIT III

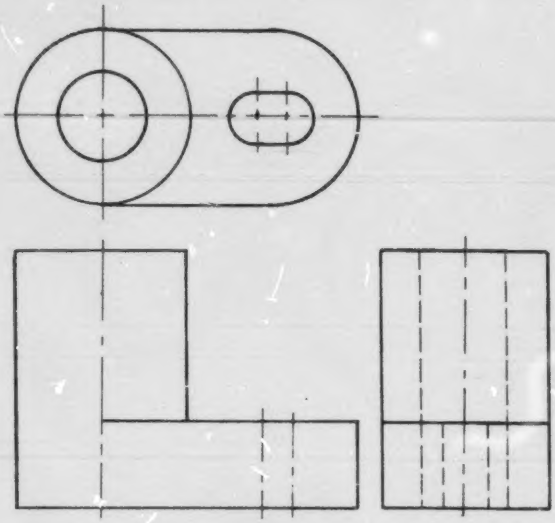
ASSIGNMENT SHEET #7--CONSTRUCT MISSING VISIBLE AND HIDDEN LINES

Directions: Study the views below and construct the missing visible and hidden lines. Align and tape down.

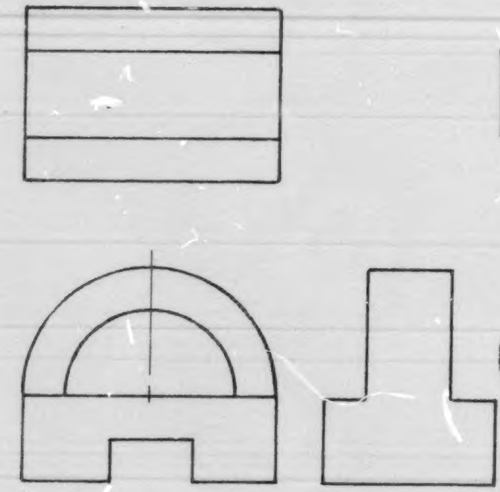
Problem A:



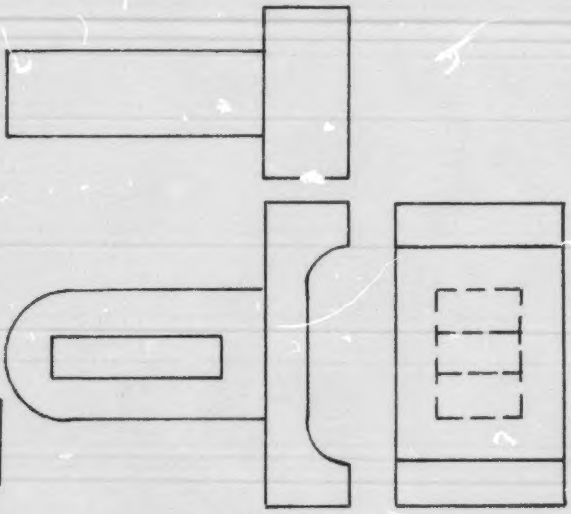
Problem B:



Problem C:

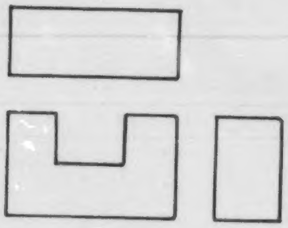


Problem D:

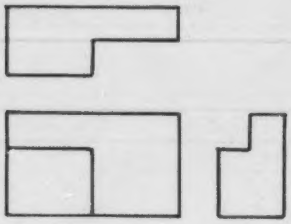


ASSIGNMENT SHEET #7

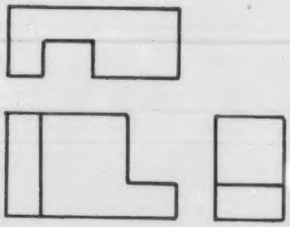
Problem E:



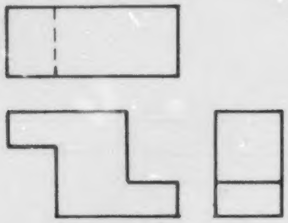
Problem F:



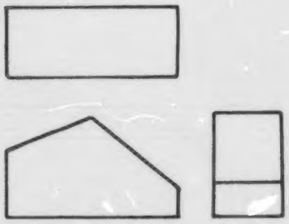
Problem G:



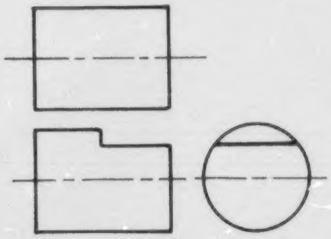
Problem H:



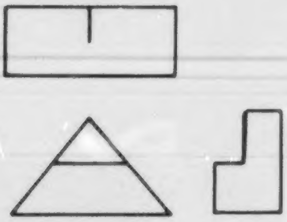
Problem I:



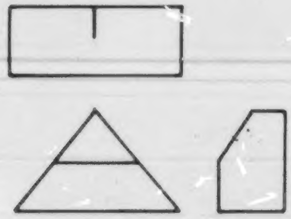
Problem J:



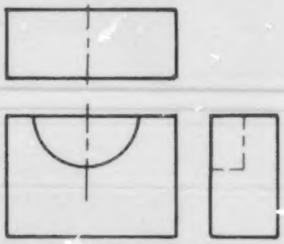
Problem K:



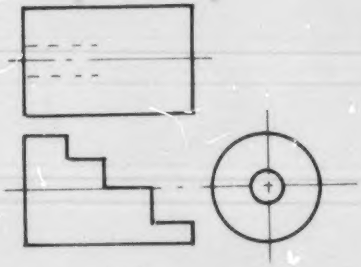
Problem L:



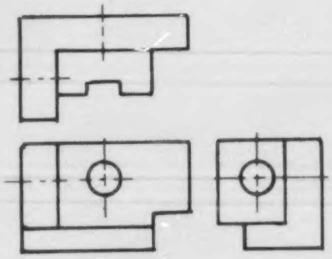
Problem M:



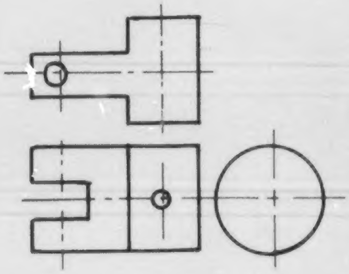
Problem N:



Problem O:



Problem P:



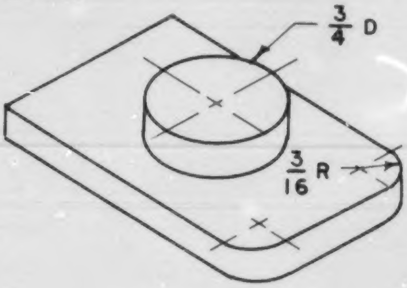
ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #8--CONSTRUCT CIRCLES AND ARCS USING A TEMPLATE

Premise: Using circle templates in constructing small circles and arcs will save time. The templates have four alignment marks that will coincide with the center lines. The template hole openings will allow for width of lead. A 3/4" hole will actually measure about 13/16". Make sure pencil is perpendicular with template. Use the procedure in the following example for circles and arcs.

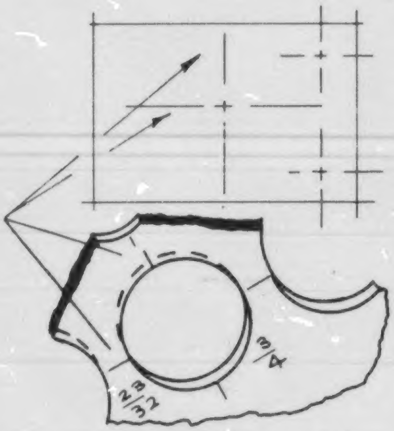
Example:

1. Block in object with light construction lines



2. Locate and construct light center lines for circles and arcs

3. Select correct hole diameter on circle template



ASSIGNMENT SHEET #8

4. Align marks on template with center lines, and construct the required circle lightly

   (NOTE: Alignment marks on some templates are not printed accurately.)

5. Select correct hole on circle template for arc radius

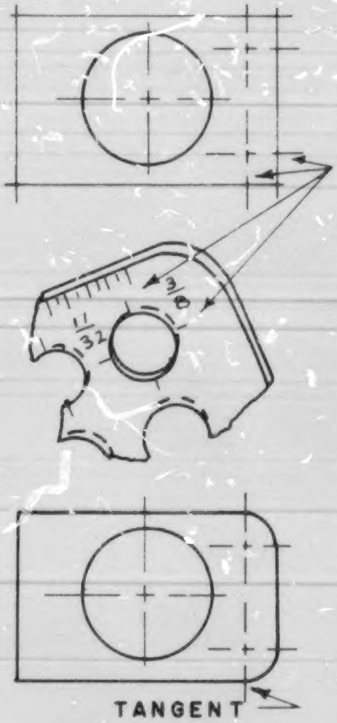
   (NOTE: Radius is equal to 1/2 diameter.)

6. Align marks on template with center lines, and construct the required arc lightly

7. Erase all construction lines not needed

8. Darken in circles and arcs first, then straight lines

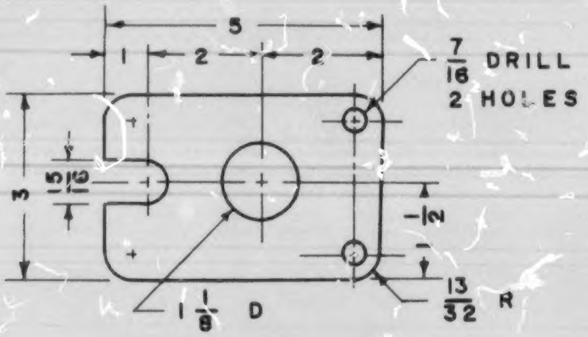
   (NOTE: Arcs tangent to straight lines should meet and align smoothly.)



ASSIGNMENT SHEET #8

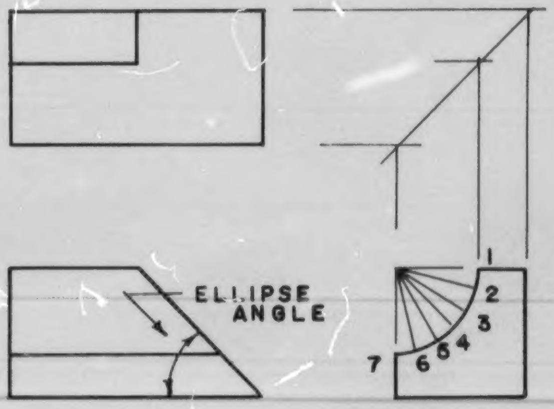
Directions: Align bottom of paper with drafting machine and tape down. Construct a one-view drawing of the gasket in the space below using a circle template. Erase construction lines and darken in visible and center lines. Do not dimension.

Problem A:



Premise: The intersection of a hole or cylinder with an inclined plane will be shown as an ellipse or elliptical curve. Ellipses can be constructed with templates or by hand. Ellipse templates are available in ellipse angles at 5° intervals, such as 15°, 20°, 25°. If an ellipse template is not available, use the procedure in the following example:

Example:



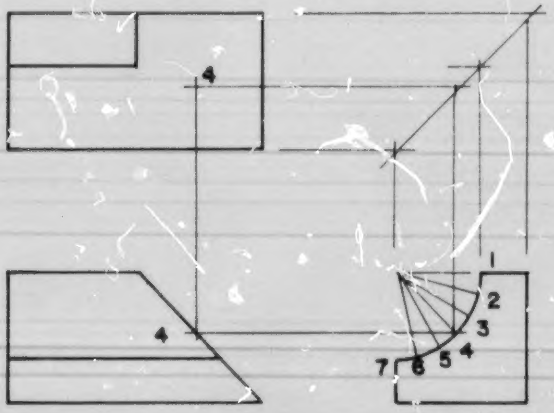
1. Construct the three views showing circle or curve and angle of inclined plane

2. Divide the curve into an equal or random number of points

   (NOTE: Several points are needed for a smooth curve.)

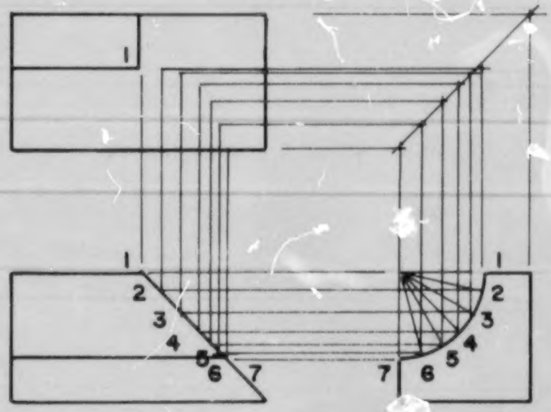
ASSIGNMENT SHEET #8

3. Project point marked No. 4 on curve to other views to intersect in top view

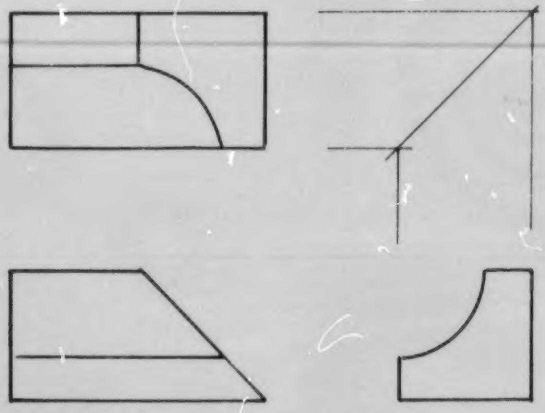


4. Project the other marked points to intersect, representing inclined edge

5. Sketch a light curved line through the intersection of points



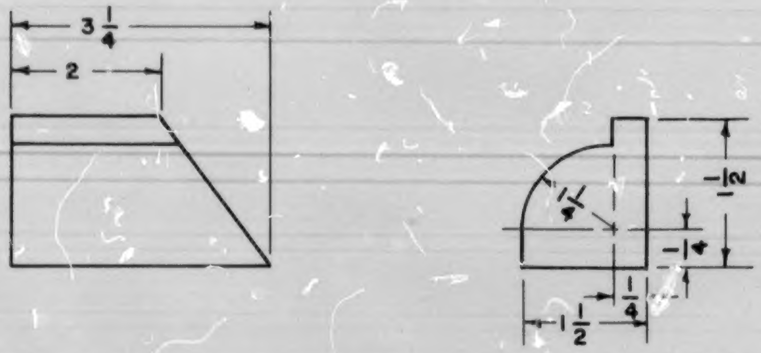
6. Erase construction lines and darken in curve line with the aid of an irregular curve



ASSIGNMENT SHEET #8

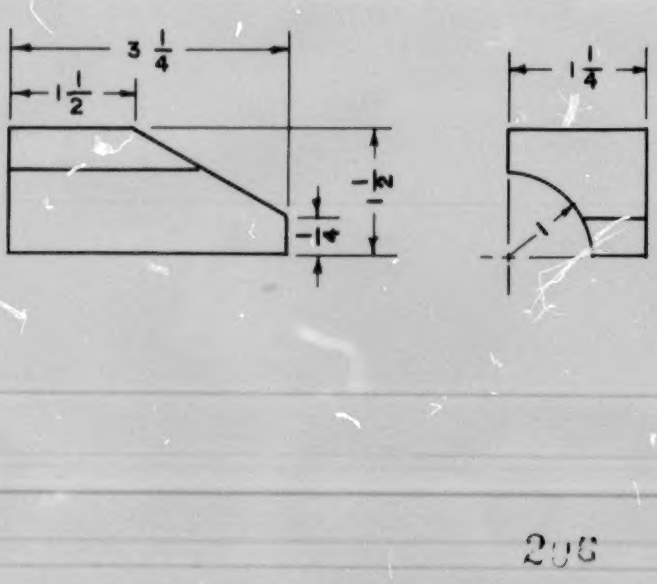
Directions: Construct three views of the following object full size on available media. Leave construction lines. Do not dimension. Leave 1" of space between views.

Problem B:



Directions: Construct three views of the following object full size on available media. Leave construction lines. Do not dimension. Leave 1" of space between views.

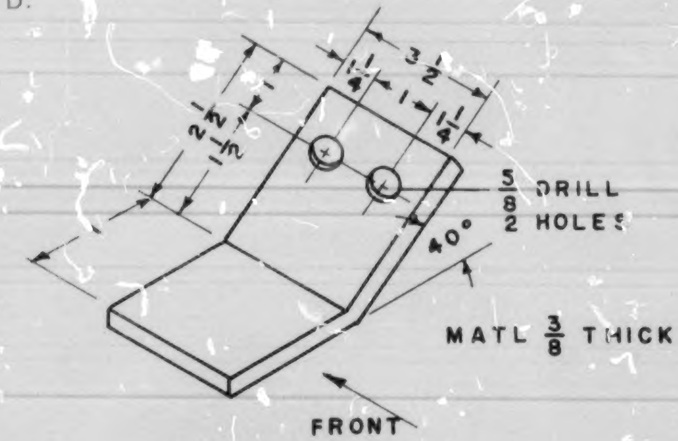
Problem C:



ASSIGNMENT SHEET #8

Directions: Construct three views of the object below full size on available media. If ellipse template is not available, use 45° inclined plane angle. Erase construction lines. Do not dimension.

Problem D:


1 1/4
3 1/2
1
1/4
1
2 1/2
1 1/2
5/8 DRILL
2 HOLES
40°
MATL 3/8 THICK
FRONT

ORTHOGRAPHIC VIEWS
UNIT III

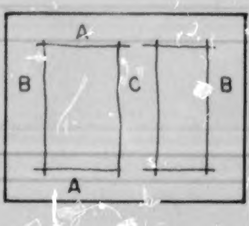
ASSIGNMENT SHEET #9--MAKE A TWO-VIEW SKETCH

Premise: A two-view sketch can be made by using the procedure in the following example.

Example:

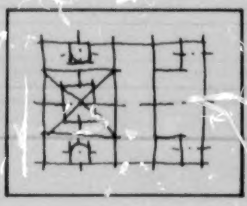
1. Sketch the horizontal lines to locate the height of the object

   (NOTE: The distance at the top and bottom of the paper should be the same.)



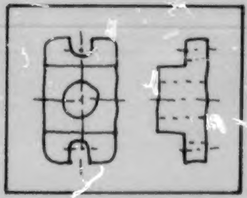
2. Sketch the vertical lines to locate the width and depth of the object

   (NOTE: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space.)



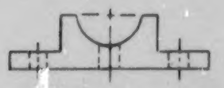
3. Block in details using diagonals to locate centers, and lightly sketch the circles and arcs

4. Use an artgum eraser to dim construction lines and darken in visible lines



Directions: Make a two-view sketch of the following object.

Problem:



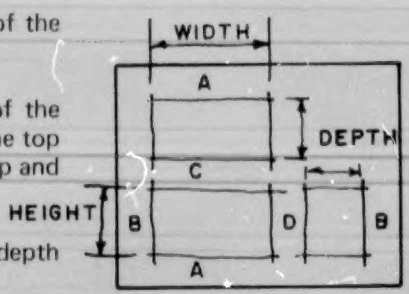
ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #10--MAKE A THREE-VIEW SKETCH

Example:

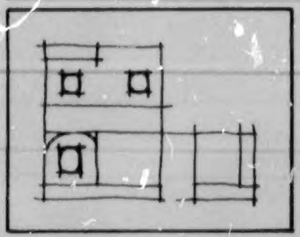
1. Sketch the horizontal lines to locate the height of the object

   (NOTE: The distance at the top and bottom of the paper should be the same. The distance between the top and front views can be the same as that on the top and bottom or slightly less than that space.)



2. Sketch the vertical lines to locate the width and depth of the object

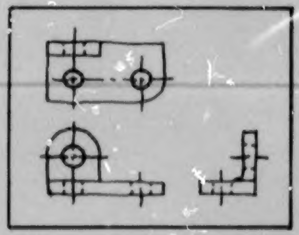
   (NOTE: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space. In the top and side views, the depth must be equal; this can be done by marking a piece of paper with depth.)



3. Block in details using diagonals to locate centers, if necessary, and lightly sketch the circles and arcs

4. Add line features to the views of the object

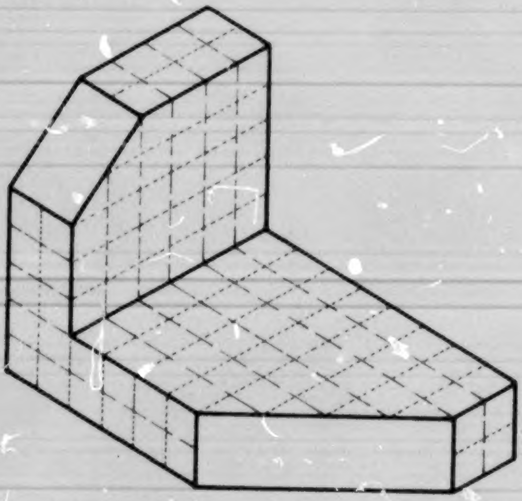
5. Use an artgum eraser to dim construction lines and darken in visible lines

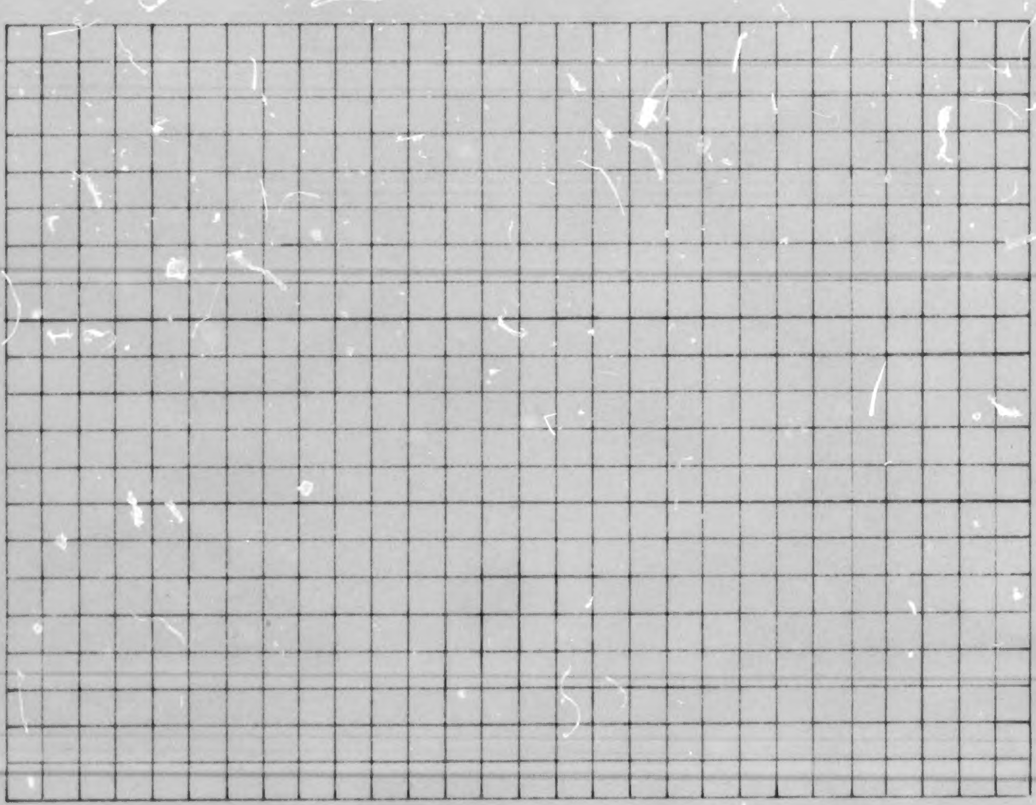


ASSIGNMENT SHEET #10

Directions: Sketch three views of the object using grids for measurements.

Problem:



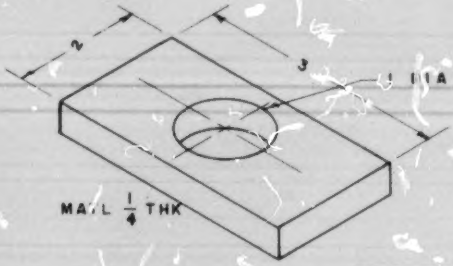


ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #11–CONSTRUCT A ONE-VIEW DRAWING

Premise: It is important for good appearance that views be well balanced on drawing media, whether the drawing shows one, two, three views, or more. Use the procedure in the following example for spacing a one-view drawing.

Example:


2
3
1 DIA
MAT'L $\frac{1}{4}$ THK

1. Locate the center of the working space by constructing diagonals (Figure 1)

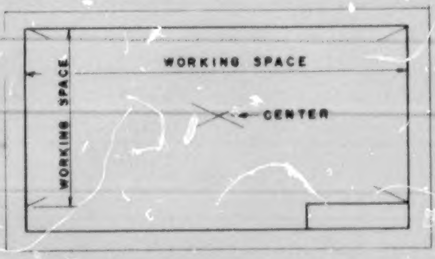

WORKING SPACE
WORKING SPACE
CENTER

FIGURE 1

2. Block in lightly horizontal construction lines by measuring the distances (Figure 2)

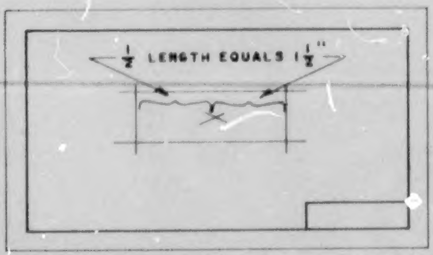

$\frac{1}{2}$ LENGTH EQUALS $1\frac{1}{2}$"

FIGURE 2

3. Block in lightly vertical construction lines by measuring the distances (Figure 3)

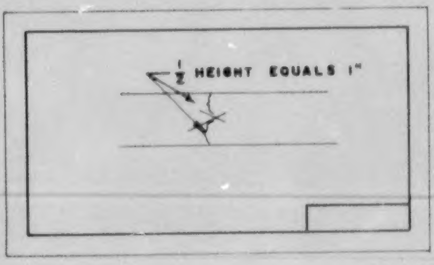

$\frac{1}{2}$ HEIGHT EQUALS 1"

FIGURE 3

ASSIGNMENT SHEET #11

4. Construct the necessary light center lines, circles, arcs and then straight lines (Figure 4)

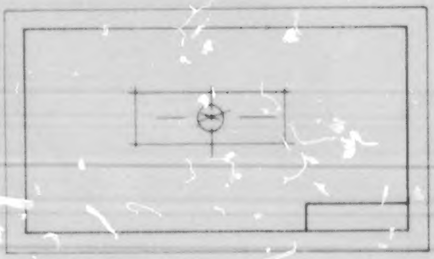


FIGURE 4

5. Erase construction lines not needed (Figure 5)

6. Darken circles and arcs first, then straight lines (Figure 5)

7. Fill in title block

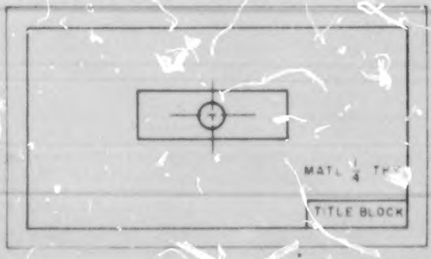
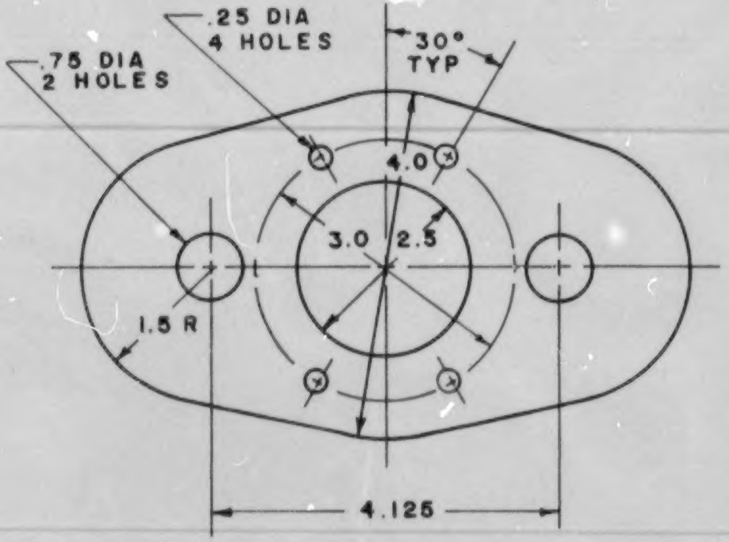

MATL 1/4 THK
TITLE BLOCK

FIGURE 5

Directions: Center and construct the gasket full size on A size vellum. Use standard title block. Do not dimension.

Problem:


.25 DIA
4 HOLES
.75 DIA
2 HOLES
30°
TYP
4.0
3.0
2.5
1.5 R
4.125

ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #12-CONSTRUCT A TWO-VIEW DRAWING

Premise: It is important for good appearance that views be well balanced on drawing media. The drafter must determine the size of the object to be drawn, number of views, scale used, and space between views. Space between views should be allotted for notes and dimensions. Use the procedure in the following example for allotted space for a two-view drawing.

Example:

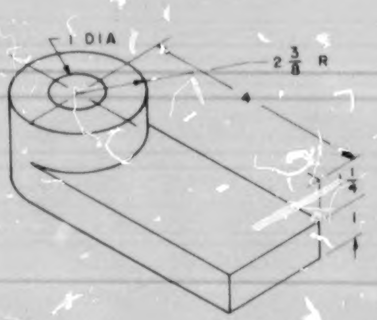
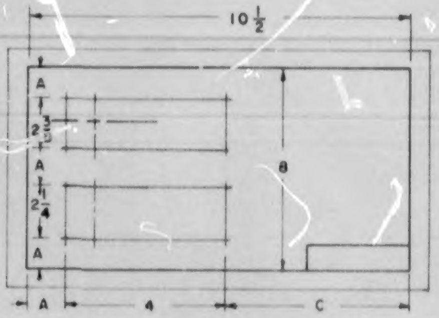


FIGURE 1

1. Calculate the spacing of views for object shown in Figure 1 (Figure 2)

   (NOTE: Spacing is assumed between views when drawing is dimensioned.)



$$2\tfrac{3}{8} + 2\tfrac{1}{4} = 4\tfrac{5}{8} \qquad 8 - 4\tfrac{5}{8} = 3\tfrac{3}{8} \div 3 = 1\tfrac{1}{8} = A$$

$$4 + 1\tfrac{1}{8} = 5\tfrac{1}{8} \qquad 10\tfrac{1}{2} - 5\tfrac{1}{8} = 5\tfrac{3}{8} = C$$

FIGURE 2

2. Block in views with light horizontal and vertical construction lines through spacing marks (Figure 2)

3. Locate center lines, and then construct light arcs and circles (Figures 2 and 3)

4. Add light visible and hidden lines (Figure 3)

   (NOTE: Do not complete one view before starting on another.)

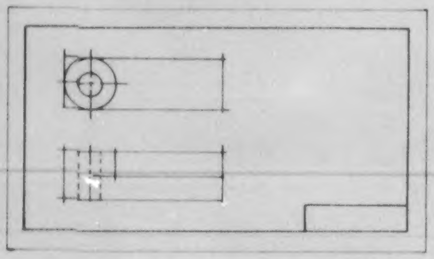


FIGURE 3

ASSIGNMENT SHEET #12

5. Erase unnecessary construction lines, and then darken in circles, hidden lines, and visible lines (Figure 4)

   (NOTE: Hidden and center lines should be thin in contrast to the visible lines, but should be dark enough to reproduce well.)

6. Letter in title block

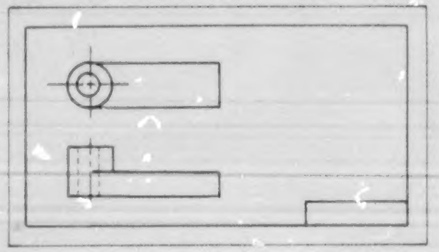
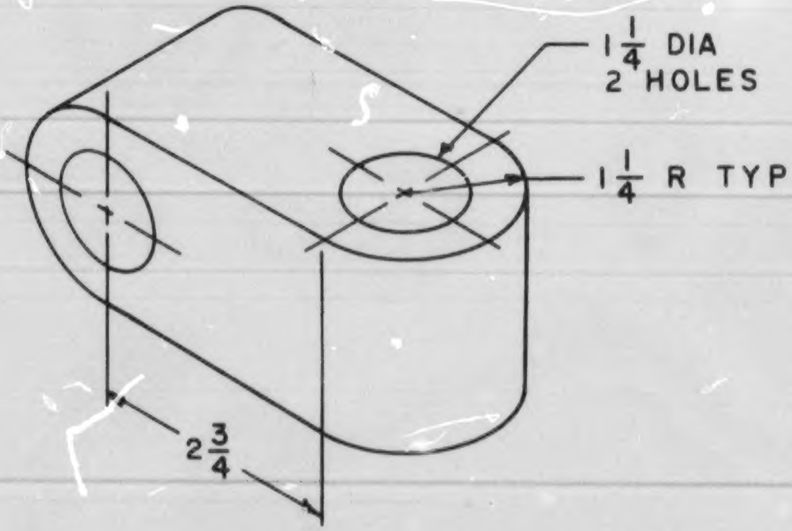


FIGURE 4

Directions: Construct two views full size on A size vellum. Use standard border and title block. Do not dimension.

Problem:



ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #13--CONSTRUCT A THREE-VIEW DRAWING

Premise: A drafter should space views so that they will give the drawing a balanced appearance. Before drawing an object, the number of views needed must be decided and a three-view drawing is sometimes required. To construct a three-view drawing use the procedure in the following example.

Example:

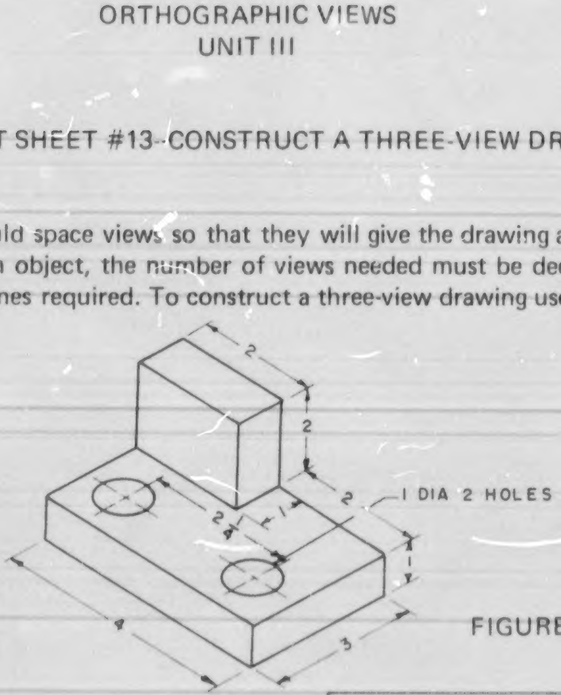


FIGURE 1

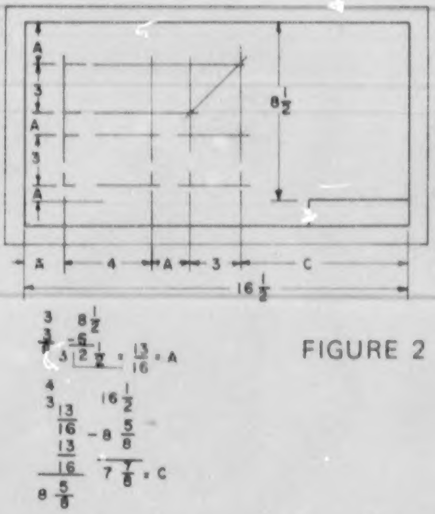


FIGURE 2

1. Select the proper surface to represent the front view for object shown in Figure 1
2. Construct a three-view sketch to determine dimension for blocking in and to clear up any uncertain details
3. Select a sheet size and scale that will avoid crowding of views, dimensions, and notes

   (NOTE: For this procedure the scale, dimensions, notes, and title block are omitted.)
4. Calculate the spacing of the views for a standard drawing sheet (Figure 2)
5. Block in views with light horizontal and vertical construction lines through spacing marks (Figure 3)

   (NOTE: Check measurements carefully when blocking in views.)

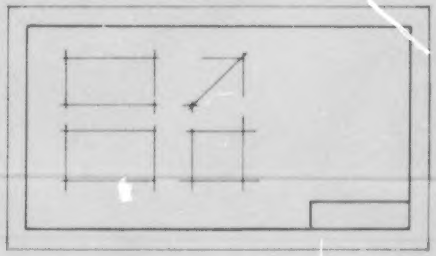


FIGURE 3

ASSIGNMENT SHEET #13

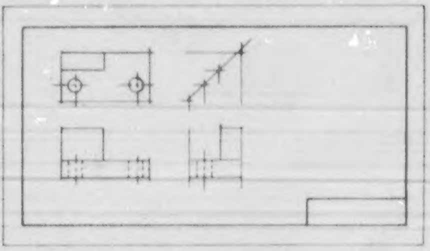


FIGURE 4

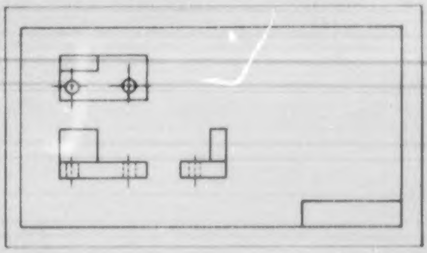


FIGURE 5

6. Construct mitre line for transferring of measurements in top and right side views (Figure 3)

7. Locate center lines and construct light arcs and circles, straight visible lines, and hidden lines (Figure 4)

   (NOTE: Check layout carefully for missing lines, notes, or special shapes required.)

8. Erase unnecessary construction lines and give drawing a good cleaning (Figure 5)

9. Darken in arcs and circles, and then center lines, hidden lines, and visible lines (Figure 5)

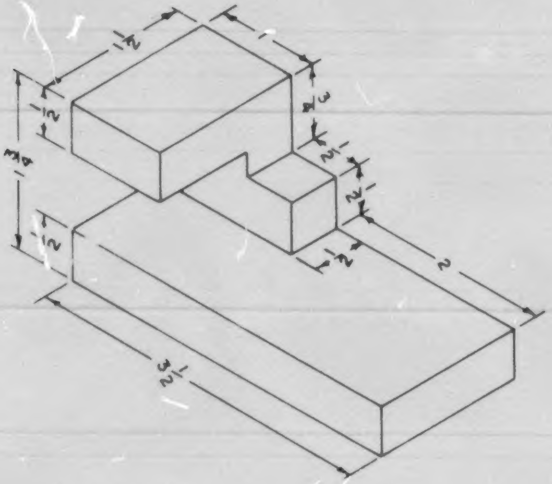
10. Letter notes and title block

11. Check finished drawing carefully for spelling, lineweight, and general appearance

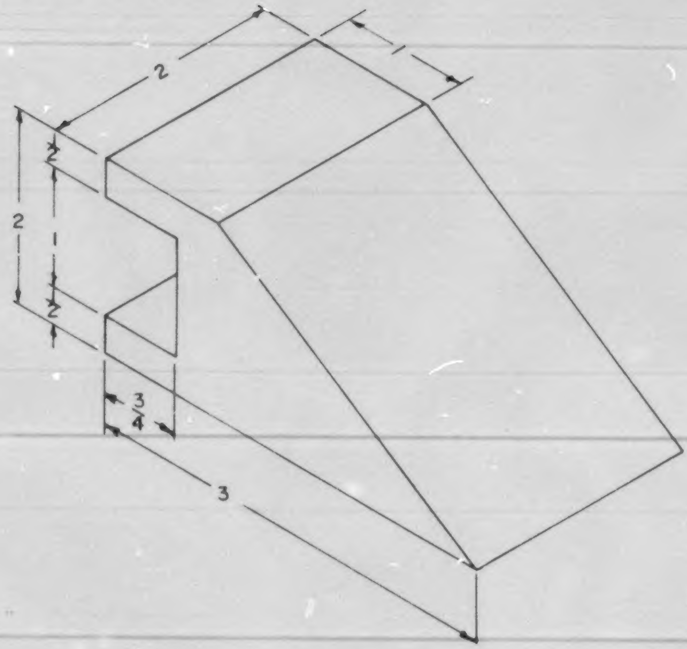
ASSIGNMENT SHEET #13

Directions: Construct three views of objects shown full size on B size vellum. Do not dimension.

Problem A: Normal surfaces


1 1/2
1
3/4
1/2
1 3/4
1/2
1/2
1/2
1/2
2
3 1/2

Problem B: Oblique surfaces


2
1
1/2
2
1
1/2
3/4
3

ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #14--CONSTRUCT A RUNOUT

Premise: The arc of the runout is the same radius as the fillet or round. It may be drawn freehand, with irregular curve, or with a circle template. The circle template procedure is used in the following example.

Example:

1. Project point of tangency from top to front view (Figure 1)

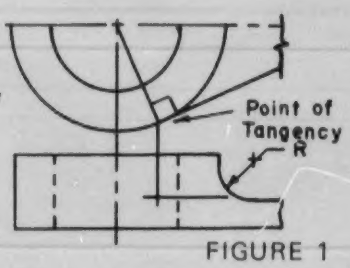


FIGURE 1

2. Construct 45° line through fillet's center to locate point A, and then project to point A' (Figure 2)

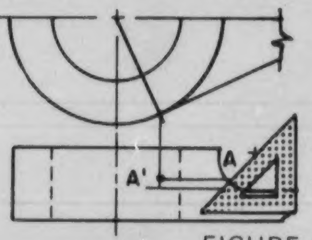


FIGURE 2

3. Center B is found by projecting from A' to 45° to the horizontal projection through B' (Figure 3)

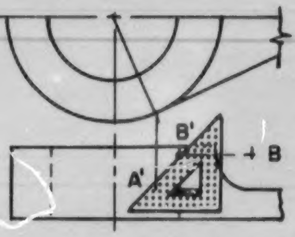


FIGURE 3

4. Use circle template to construct runout arc from A' using center B (Figure 4)

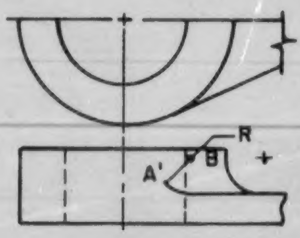
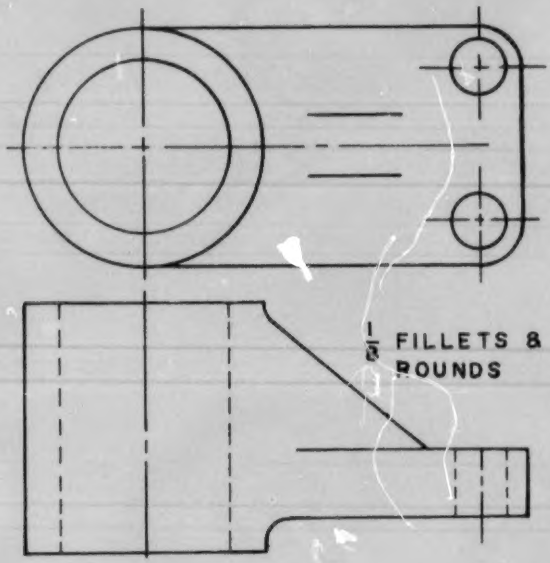


FIGURE 4

ASSIGNMENT SHEET #14

Directions: Align the horizontal center line of the object below with drafting machine. Tape down. Construct the runouts. Do not erase construction lines.

Problem:


$\frac{1}{8}$ FILLETS & ROUNDS

ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #15--CONSTRUCT A POINT IN AN ORTHOGRAPHIC VIEW

Premise: A point in space has position but no extension such as the intersections of two lines. Three dimensions are necessary to fix its position in space. The procedure for the orthographic projection of one point will be used in the following example.

Example:

1. Use given point A in two views (Figure 1)
2. Project perpendicular lines from point A to reference lines RL1 and RL2 (Figure 1)

   (NOTE: Light projected lines perpendicular to reference lines should be used to align the projections.)
3. Construct mitre line to project depth dimension from top to right side or right side to top (Figure 1)

   (NOTE: This is needed only to establish position in top view or right side view.)
4. Project point S_{AT} and A_F to intersect in right side view to establish point in third view (Figure 2)

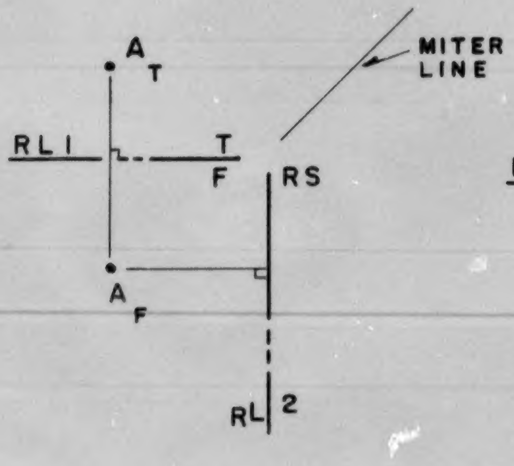


FIGURE 1

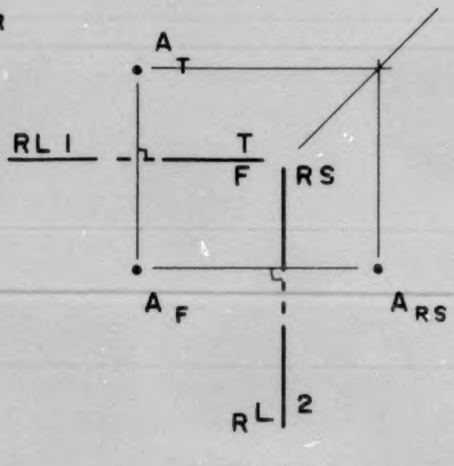
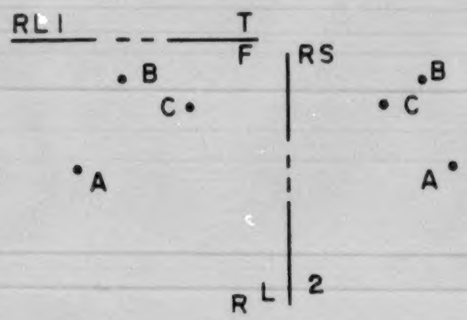


FIGURE 2

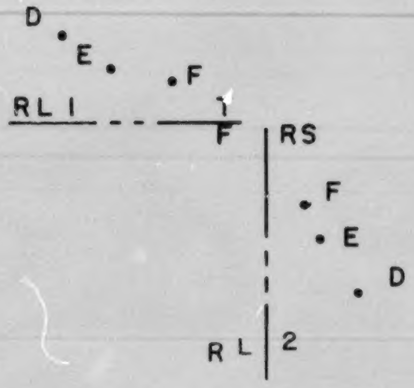
ASSIGNMENT SHEET #15

Directions: Align drafting machine with reference line and tape down for the following problems. Leave construction lines. Construct the points in the third view. Label points in third view.

Problem A:


RL 1
T
F
RS
B
C
A
B
C
A
R L
2

Problem B:


D
E
F
RL 1
T
F
RS
F
E
D
R L
2

ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #16--CONSTRUCT A LINE IN AN ORTHOGRAPHIC VIEW

Premise: Lines are grouped into types as normal, inclined, or oblique, depending on how they are positioned with relationship to the reference lines. The procedure in the following example for oblique lines can be used for inclined or normal lines.

Example:

1. Use given line AB in two views (Figure 1)

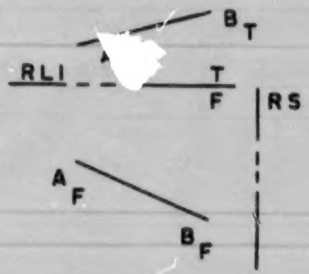


FIGURE 1

2. Project perpendicular lines from points A and B to reference lines RL1 and RL2 (Figure 2)
3. Construct mitre line to project depth dimensions from top to right side or right side to top view (Figure 2)

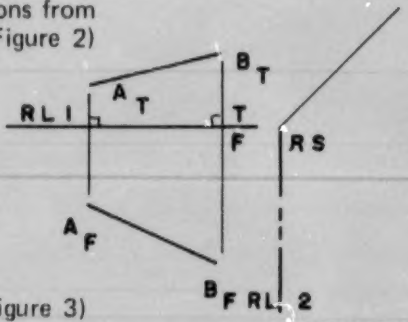


FIGURE 2

4. Project points A_T, B_T and A_F, B_F to right side view, locating points A_{RS}, B_{RS} (Figure 3)

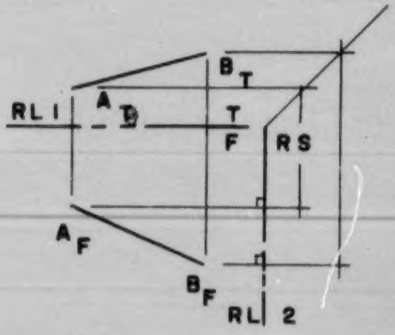
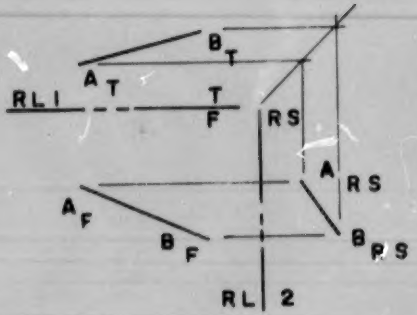


FIGURE 3

ASSIGNMENT SHEET #16

5. Connect points A_{RS}, B_{RS} with a line (Figure 4)

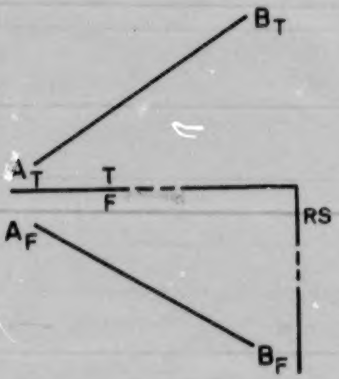


B_T
A_T
RL 1
T
F
RS
A RS
A_F
B_F
B RS
RL 2

FIGURE 4

Directions: Align drafting machine with reference line and tape sheet down. Construct the third view of the line or lines given in the space provided.

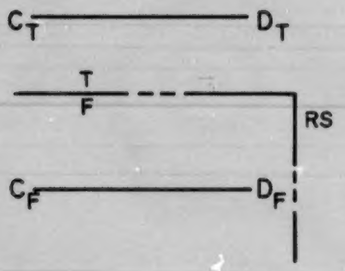
Problem A:



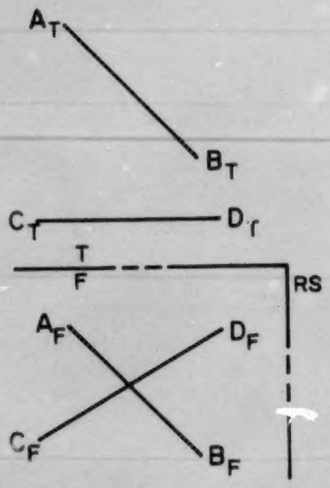
B_T
A_T
T
F
RS
A_F
B_F

ASSIGNMENT SHEET #16

Problem B:

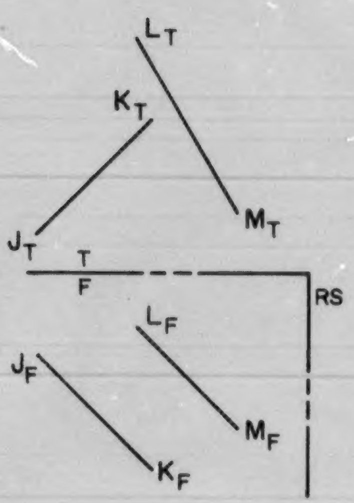

C_T
D_T
T
F
RS
C_F
D_F

Problem C:


A_T
B_T
C_T
D_T
T
F
RS
A_F
D_F
C_F
B_F

ASSIGNMENT SHEET #16

Problem D:


L_T
K_T
M_T
J_T
T
F
RS
L_F
J_F
M_F
K_F

ORTHOGRAPHIC VIEWS
UNIT III

ASSIGNMENT SHEET #17--CONSTRUCT A PLANE IN AN ORTHOGRAPHIC VIEW

Premise: Planes are without thickness. A plane may be constructed by intersecting lines, two parallel lines, a line and a point, three points, or a triangle. The procedure in the following example is for constructing the third view when two views are given.

Example:

1. Use given plane ABC in two views (Figure 1)

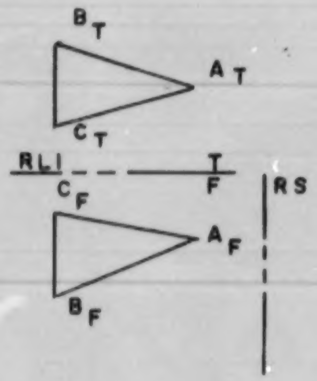


FIGURE 1

2. Project perpendicular lines from points A, B, and C, to reference lines RL1 and RL2 (Figure 2)

3. Construct mitre line to project depth dimension from top to right side or right side to top view (Figure 2)

4. Project points A_T, B_T, C_T, and A_F, B_F, C_T, to right side view, locating points A_{RS}, B_{RS}, C_{RS} (Figure 3)

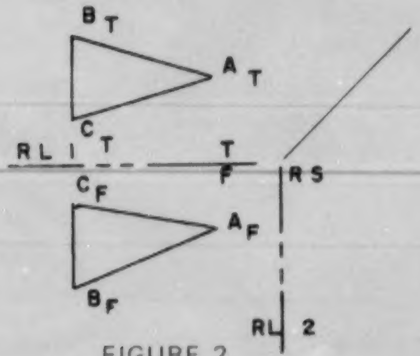


FIGURE 2

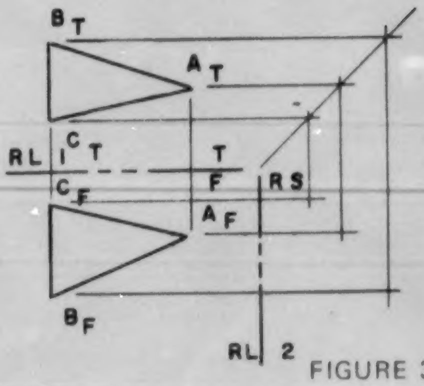
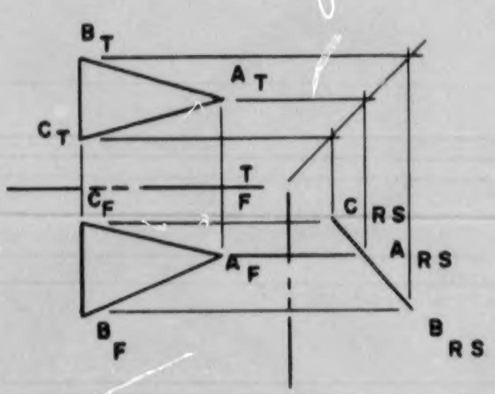


FIGURE 3

ASSIGNMENT SHEET #17

5. Connect points A_{RS}, B_{RS}, C_{RS} with lines to form plane (Figure 4)

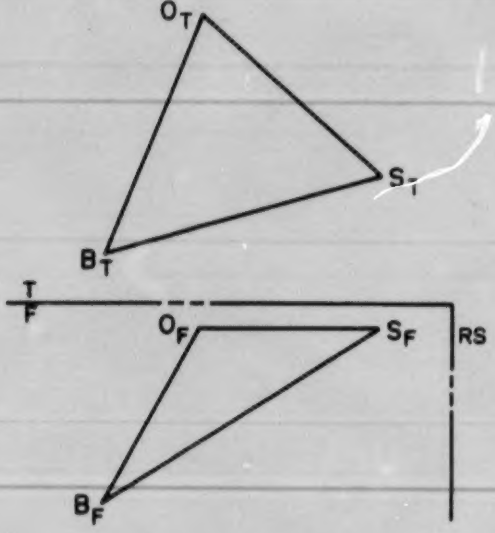


B_T
A_T
C_T
T
F
C_F
C_{RS}
A_{RS}
A_F
B_F
B_{RS}

FIGURE 4

Directions: Align drafting machine with reference line and tape sheet down. Construct the third view of the plane given in the space provided.

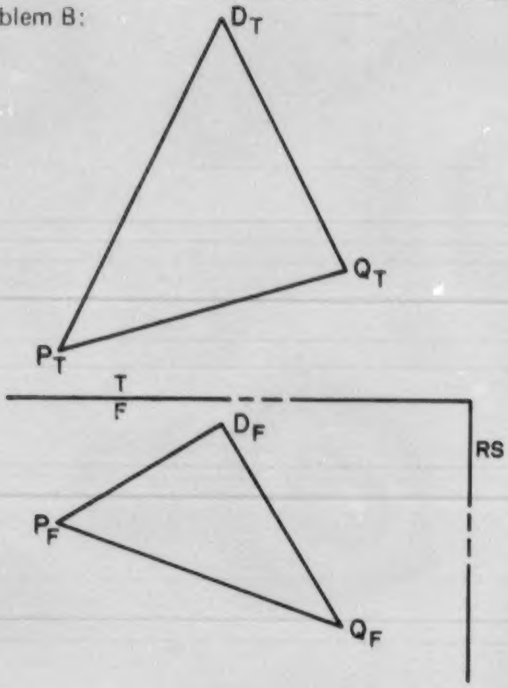
Problem A:



O_T
S_T
B_T
T
F
O_F
S_F
RS
B_F

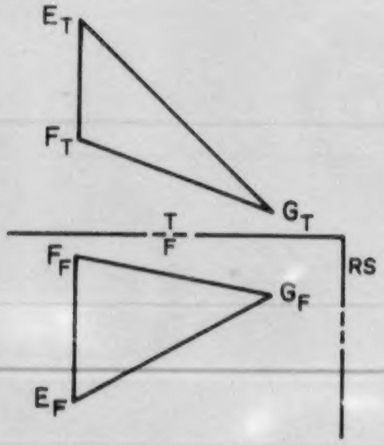
ASSIGNMENT SHEET #17

Problem B:



D_T
Q_T
P_T
T
F
D_F
RS
P_F
Q_F

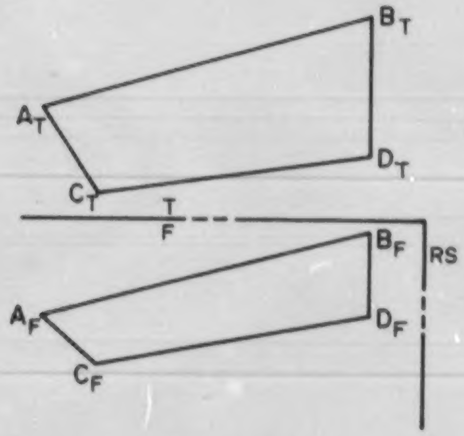
Problem C:



E_T
F_T
G_T
T
F
F_F
RS
G_F
E_F

ASSIGNMENT SHEET #17

Problem D:


B_T
A_T
D_T
C_T
T
F
B_F
RS
A_F
D_F
C_F

ORTHOGRAPHIC VIEWS
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A.

PLANE	TYPE
A	Normal
B	Normal
C	Normal
D	Normal
E	Normal
F	Inclined
G	Inclined

B.

PLANE	TYPE
A	Normal
B	Normal
C	Normal
D	Inclined
E	Oblique
F	Oblique
G	Normal

Assignment Sheet #2

A.

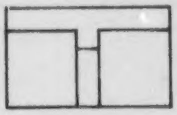
Line	Top	Front	R.Side
1	TL	Point	TL
2	TL	Point	TL
3	FS	TL	FS
4	TL	FS	FS
5	TL	TL	Point
6	Point	TL	TL
7	TL	Point	TL
8	Point	TL	TL
9	FS	TL	FS

B.

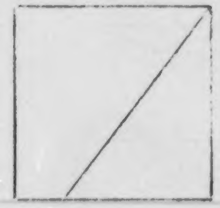
Line	Top	Front	R.Side
1	TL	TL	Point
2	FS	FS	FS
3	FS	FS	FS
4	TL	Point	TL
5	TL	FS	FS
6	TL	TL	Point
7	TL	FS	FS
8	TL	FS	FS
9	FS	FS	FS

Assignment Sheet #3

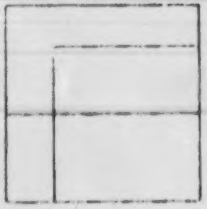
A.



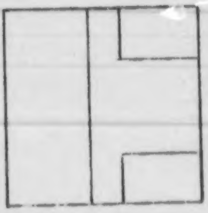
B.



C.

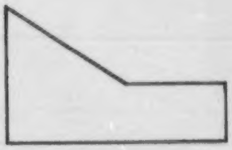


D.

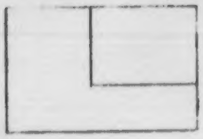


Assignment Sheet #4

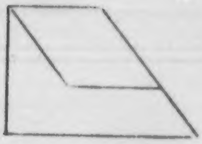
A.



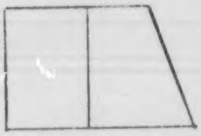
B.



C.

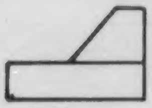


D.

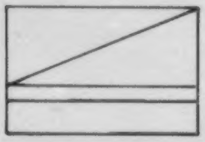


Assignment Sheet #5

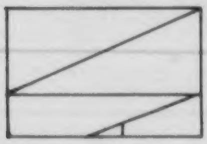
A.



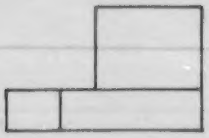
B.



C.

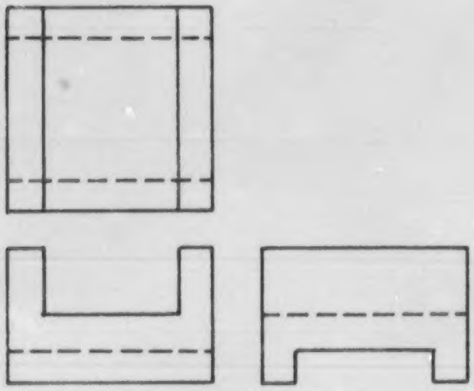


D.

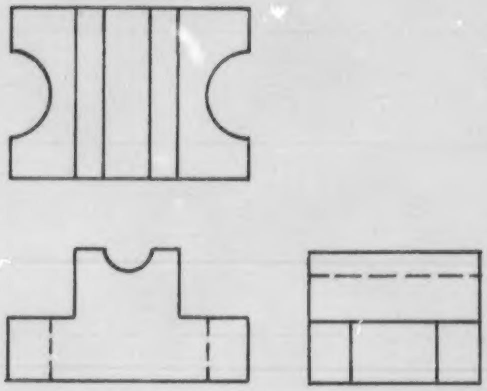


Assignment Sheet #6

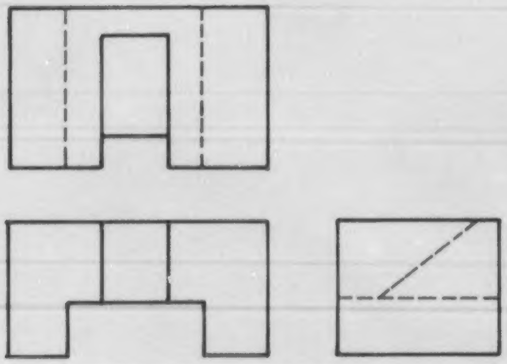
A.



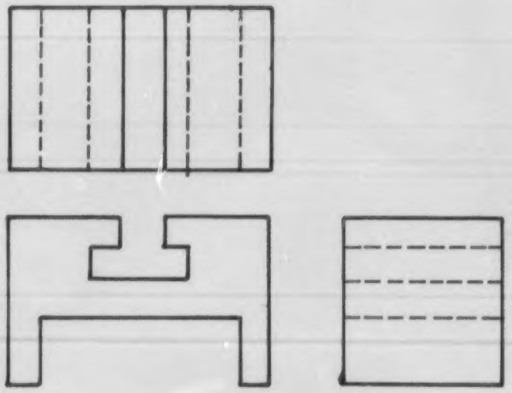
B.



C.

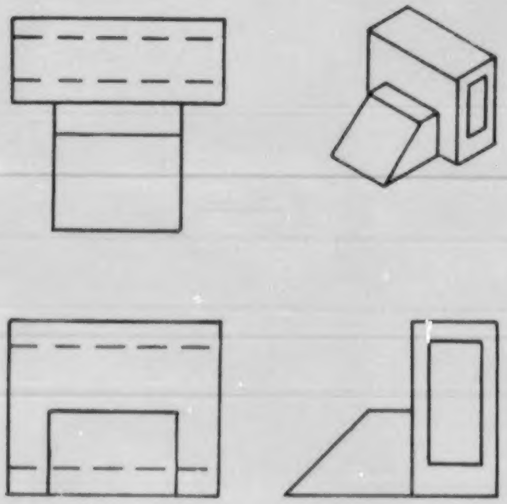


D.



Assignment Sheet #7

A.



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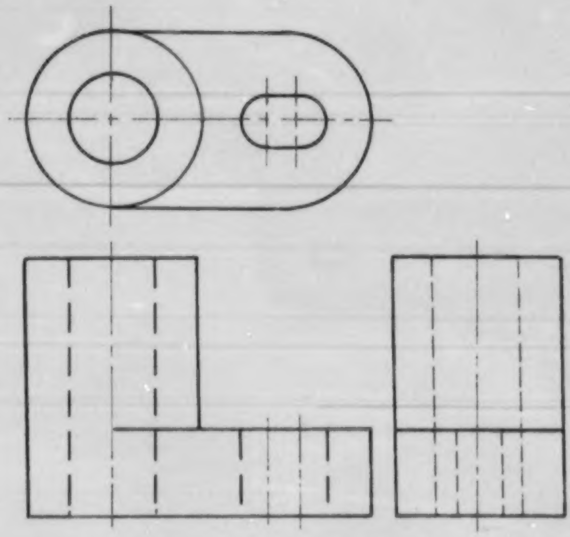

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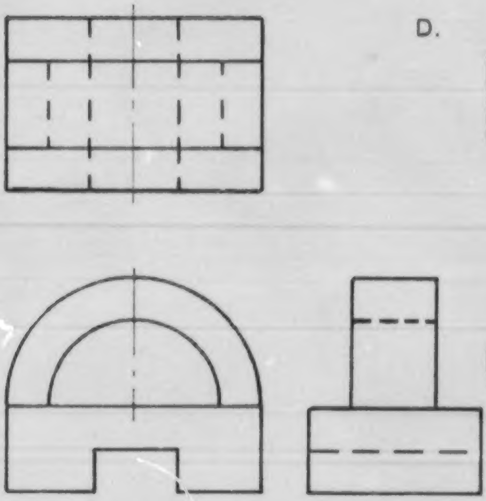

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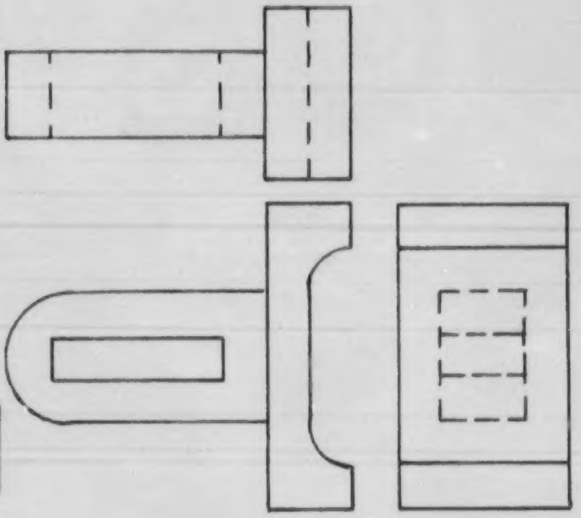

Assignment Sheet #7

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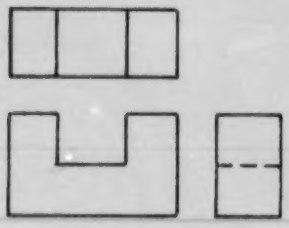

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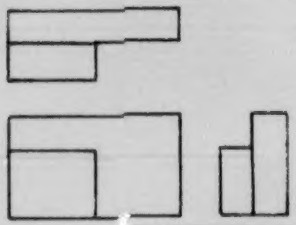

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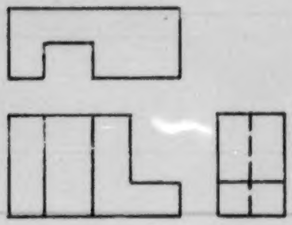

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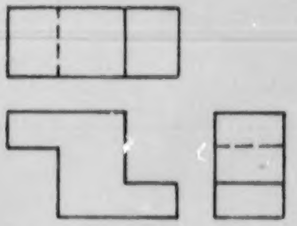

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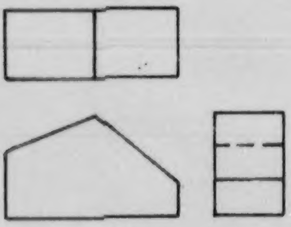

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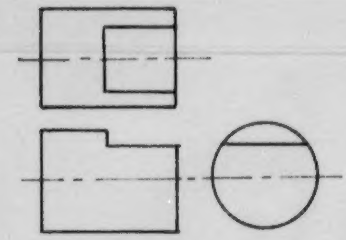

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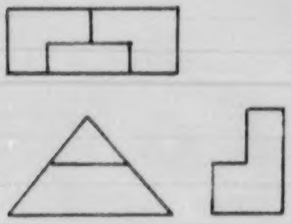

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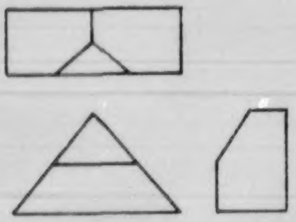

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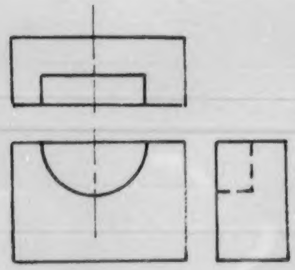

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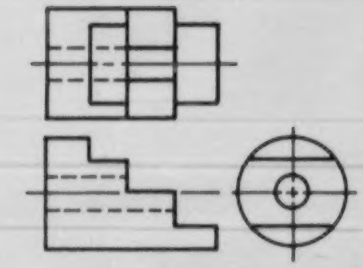

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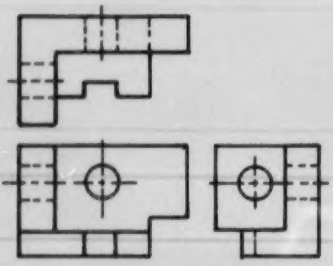

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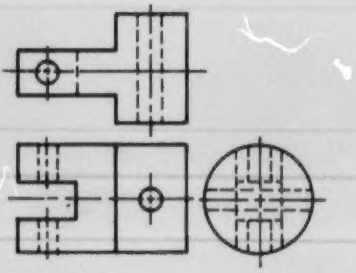
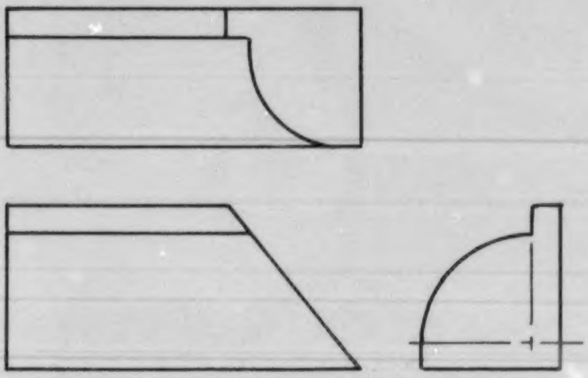


Assignment Sheet #8

A. Evaluated to satisfaction of the instructor

B.



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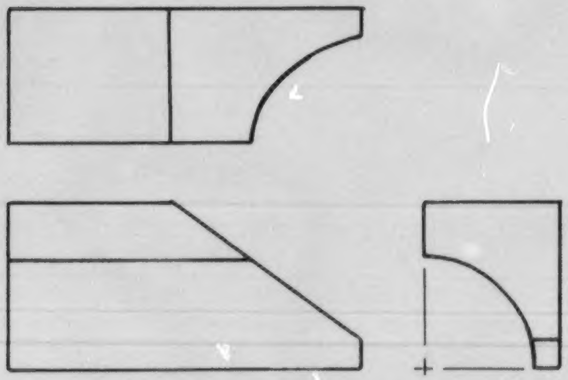

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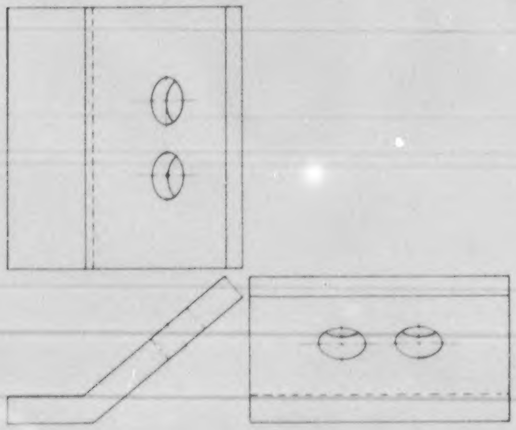
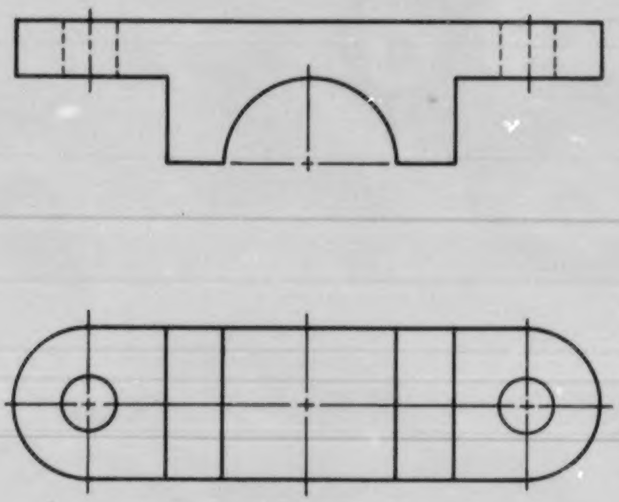
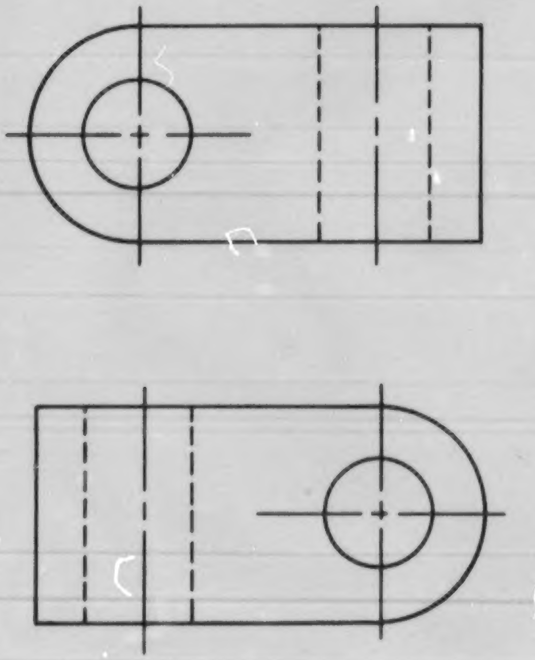


Assignment Sheet #9

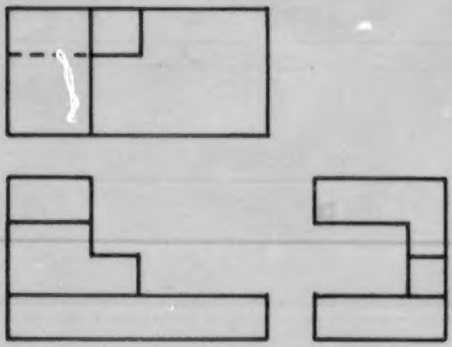


Assignment Sheet #12

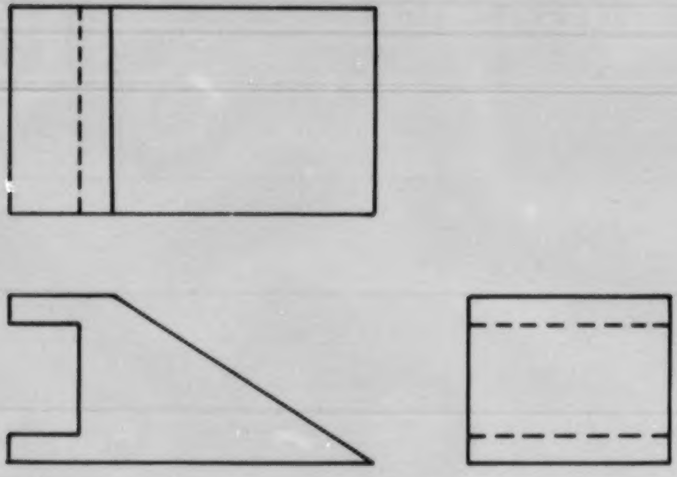


Assignment Sheet #13

A.



B.



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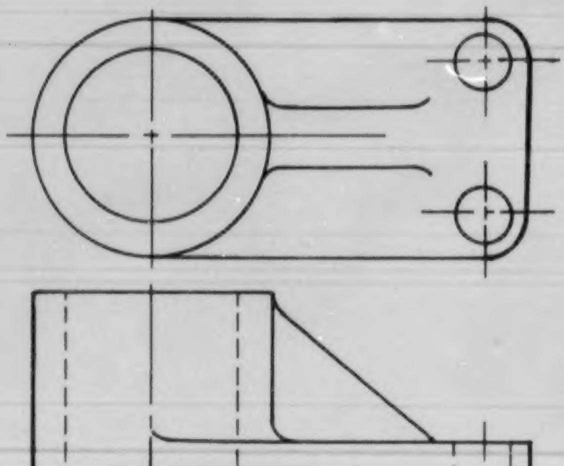

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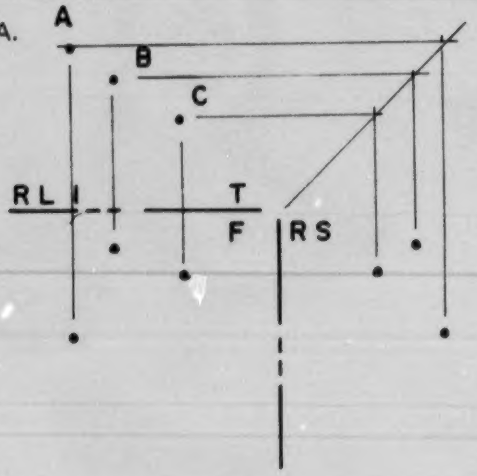
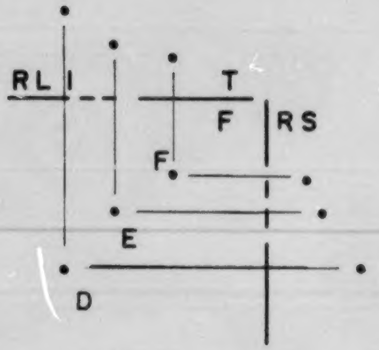
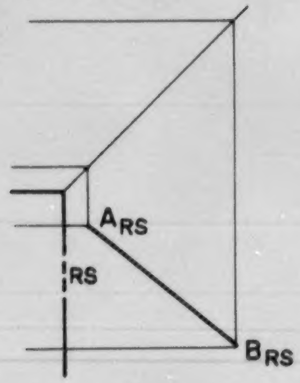

A
B
C
R L I
T
F
R S

B.


R L I
T
F
R S
F
E
D

Assignment Sheet #16

A.



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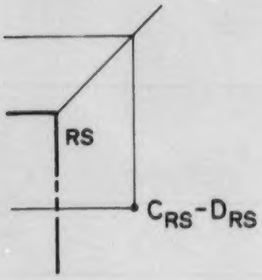

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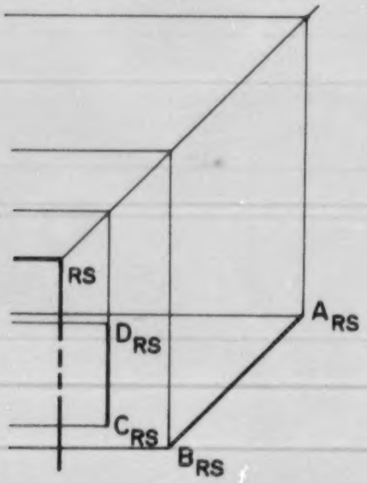
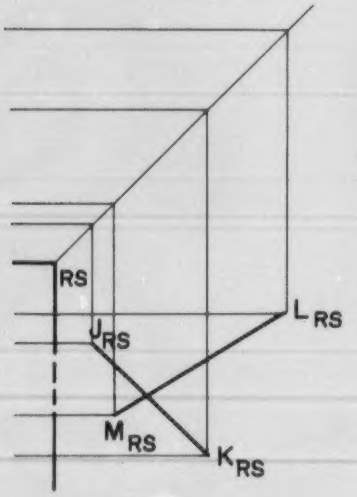
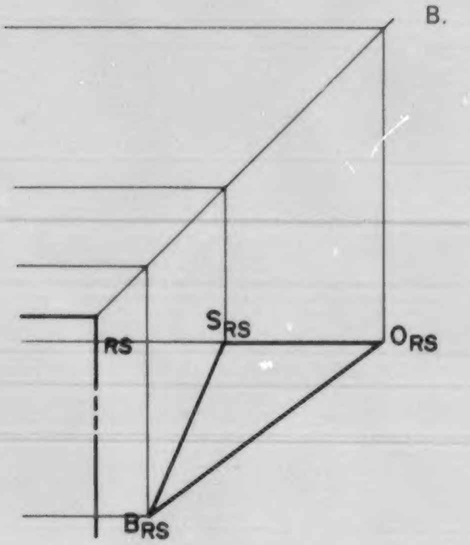

RS
A_{RS}
D_{RS}
C_{RS}
B_{RS}

D.

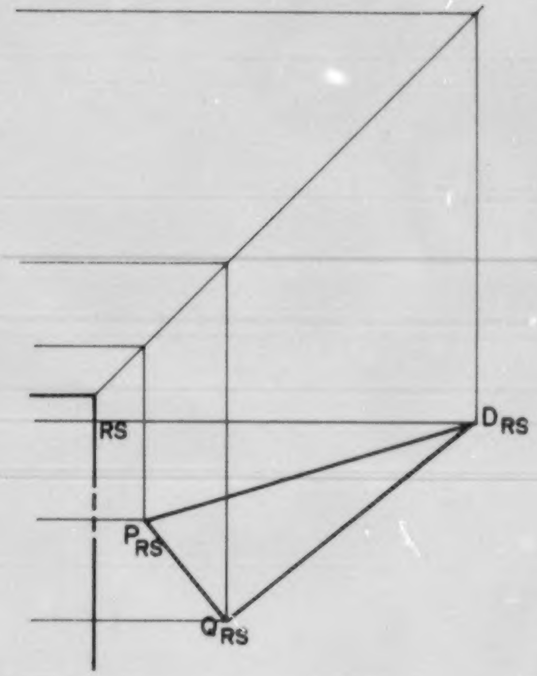

RS
L_{RS}
J_{RS}
M_{RS}
K_{RS}

Assignment Sheet #17

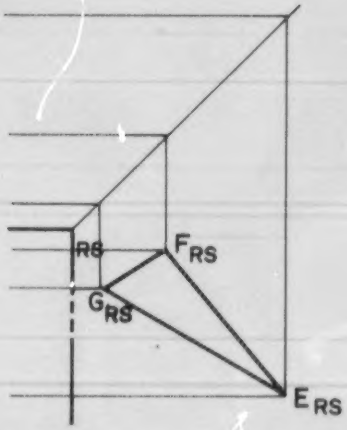
A.


RS
S_{RS}
O_{RS}
B_{RS}

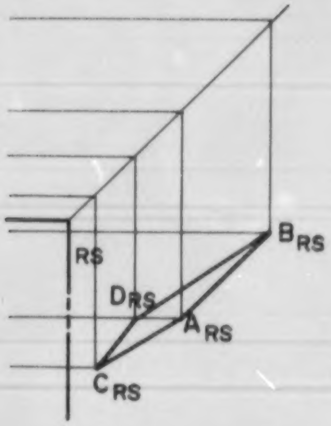
B.


RS
D_{RS}
P_{RS}
Q_{RS}

C.


RS
F_{RS}
G_{RS}
E_{RS}

D.


RS
B_{RS}
D_{RS}
A_{RS}
C_{RS}

ORTHOGRAPHIC VIEWS
UNIT III

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Method of representing the exact shape of an object in two or more views on planes at right angles to each other

______b. All views are projected onto planes located behind the object

______c. All views are projected onto planes lying between the object and viewer

______d. Lines used to extend from one view to the next view

______e. Distance from bottom to top plane

______f. Distance from left side to right side plane

______g. Distance from front to back plane

______h. True size plane that is parallel to one principal viewing plane and edge view in other two principal planes

______i. A plane that is foreshortened in two principal viewing planes and edge view in one other principal viewing plane

______j. A plane that is foreshortened in all three principal viewing planes

______k. To appear shorter to the eye than it actually is

______l. To form a mental picture or image

______m. Front view

______n. Left side or right side view

______o. Top view

______p. A surface or line that is shown in its actual size

______q. A theoretical line between two views where viewing planes fold

1. Skew lines
2. Fold line
3. Horizontal view
4. Frontal view
5. Oblique plane
6. Line
7. Round
8. Profile view
9. Fillet
10. Length
11. First-angle projection
12. Coincide
13. Visualize
14. Projection lines
15. Runout
16. Height
17. Line precedence

______r. Direction from which an object is being viewed

______s. Take from one point of view and put in another view

______t. To match up identically

______u. Lines that are more important to show than others

______v. Nonintersecting lines, not parallel to each other or to the principal views

______w. Intersection of a fillet or round with another surface

______x. Small rounded inside corner of an object

______y. Small rounded outside corner of an object

______z. Straight element that is generated by a moving point and has extension only along the path of the point

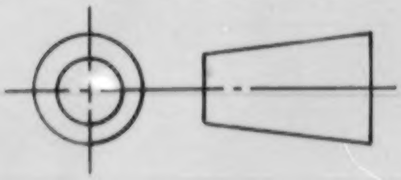
18. Foreshortened
19. Orthographic projection
20. Inclined plane
21. True size
22. Third-angle projection
23. Depth
24. Normal plane
25. Line of sight
26. Transfer

2. Distinguish between the types of projection systems by placing an "X" next to the type used in the United States.

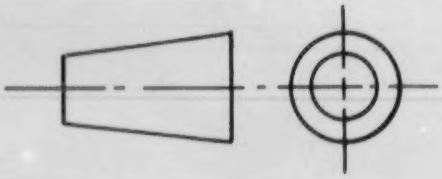
______a. First-angle

______b. Third-angle

3. Identify the ISO projection symbols.



a. ______________________________



b. ______________________________

4. Arrange in order the steps in visualizing an orthographic projection by placing the correct sequence numbers in the appropriate blanks.

   _____a. To obtain views, project the lines of sight to each plane of projection from all points on the object

   _____b. Inspect views and determine those needed to adequately represent the object

   _____c. Visualize by looking at the actual object or picture of the object

   _____d. Rotate all planes until they align with front plane of projection

   _____e. Visualize the six possible views of the object that are revolved into the same plane as on a drawing surface

5. List the six views possible in orthographic projection.

   a. ______________________ d. ______________________

   b. ______________________ e. ______________________

   c. ______________________ f. ______________________

6. List the three most commonly used views in orthographic projection.

   a. ____

   b. ____

   c. ____

7. Select true statements concerning the steps in selecting correct views of an object by placing an "X" in the appropriate blanks.

   _____a. Select view necessary to best describe contour shape in right side view

   _____b. Select the view that contains the greatest number of hidden lines

   _____c. Select only needed views necessary to present an understanding of an object

   _____d. If there is no other option, select the view that best describes the object

   _____e. Select view positions to avoid crowding of dimensions and notes

8. List the basic dimensions of an object.

a. ______________________________

b. ______________________________

c. ______________________________

9. List the most common methods of transferring dimensions.

a. ______________________________

b. ______________________________

c. ______________________________

10. Select the projection of lines in orthographic views by placing an "X" in the appropriate blanks.

_____a. Foreshortened

_____b. Skew

_____c. Point

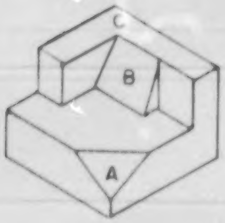
_____d. True length

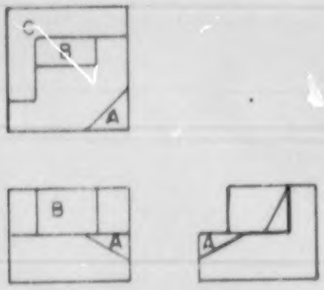
11. Identify types of planes.

a. A planes ______________________________

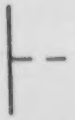
b. B planes ______________________________

c. C planes ______________________________





12. Select the correct usage of hidden lines by placing an "X" in the appropriate blanks.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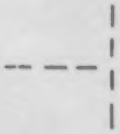
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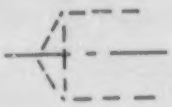
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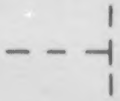
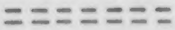
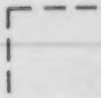

d.________


e.________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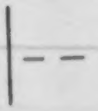
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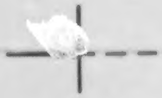
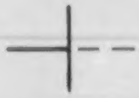
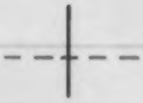

h.________


i.________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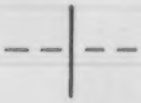
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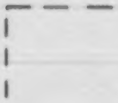
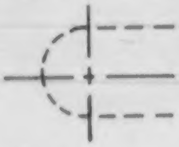

l.________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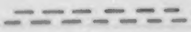
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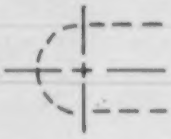

o.________

13. Select correct line precedence in an orthographic drawing by placing an "X" in the appropriate blanks.

_____c. cutting plane line

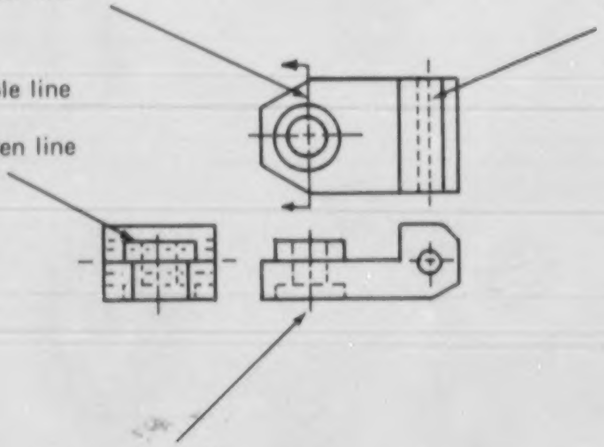
_____d. center line

_____g. center line

_____h. hidden line

_____e. visible line

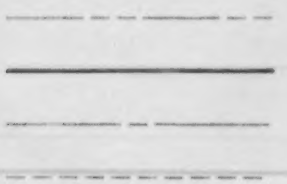
_____f. hidden line



_____a. center line

_____b. visible line

14. Identify line thicknesses used in orthographic drawings.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

15. State the purpose of runouts.

____

____

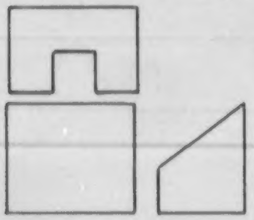
16. Demonstrate the ability to:

   a. Identify types of planes in orthographic views.
   b. Identify projection of lines in orthographic views.
   c. Construct a top view.
   d. Construct a front view.
   e. Construct a right side view.
   f. Construct missing hidden lines.
   g. Construct missing visible and hidden lines.
   h. Construct circles and arcs using a template.
   i. Make a two-view sketch.
   j. Make a three-view sketch.
   k. Construct a one-view drawing.
   l. Construct a two-view drawing.
   m. Construct a three-view drawing.
   n. Construct a runout.
   o. Construct a point in an orthographic view.
   p. Construct a line in an orthographic view.
   q. Construct a plane in an orthographic view.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

17. Construct various orthographic drawings.

a. Complete the missing lines and views.



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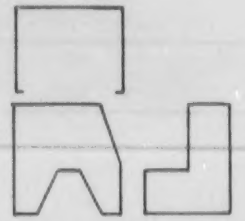
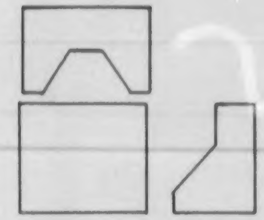


2)



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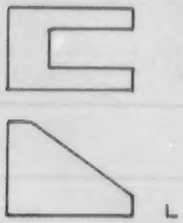

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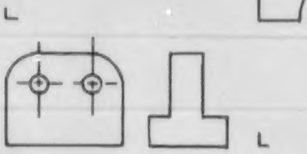

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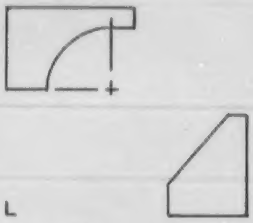
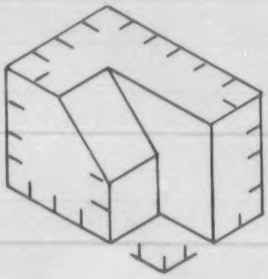
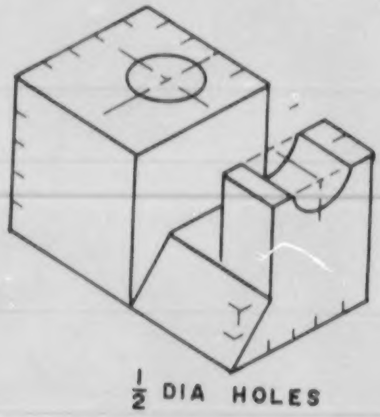


6)

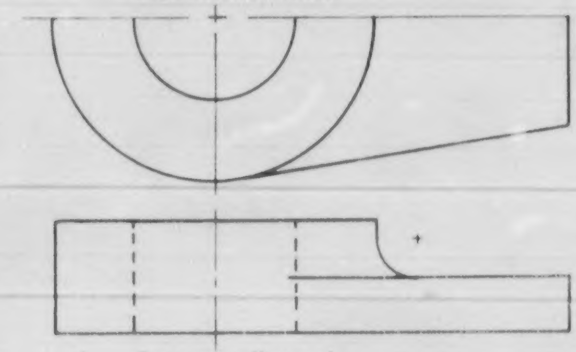
b. Construct three views of the object full size shown in pictorial. Begin the views using the corners given. Each mark is equal to 1/4".



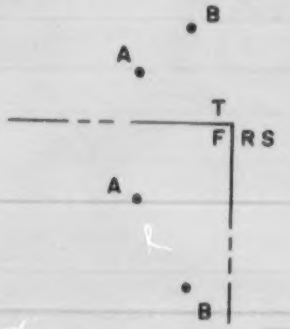
c. Construct three views of the object full size shown in pictorial. Each mark is equal to 1/4".


$\frac{1}{2}$ DIA HOLES

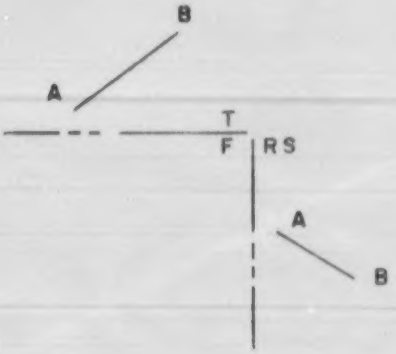
d. Construct a runout. Leave construction lines.



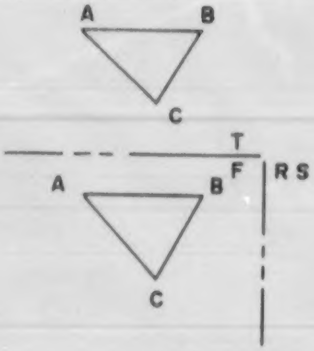
e. Construct points A and B in right side view.



f. Construct line as in front view.



g. Construct plane ABC in right side view.


A
B
C
T
F
RS
A
B
C

ORTHOGRAPHIC VIEWS
UNIT III

ANSWERS TO TEST

1. a. 19
   b. 11
   c. 22
   d. 14
   e. 16
   f. 10
   g. 23
   h. 24
   i. 20
   j. 5
   k. 18
   l. 13
   m. 4
   n. 8
   o. 3
   p. 21
   q. 2
   r. 25
   s. 26
   t. 12
   u. 17
   v. 1
   w. 15
   x. 9
   y. 7
   z. 6

2. b

3. a. Third-angle
   b. First-angle

4. a. 2
   b. 5
   c. 1
   d. 3
   e. 4

5. a. Top
   b. Front
   c. Right side
   d. Left side
   e. Bottom
   f. Rear

6. a. Top
   b. Front
   c. Right side

7. c, d, e,

8. a. Length
   b. Height
   c. Depth

9. a. 45° mitre line
   b. Dividers
   c. Scale

10. a, c, d

11. a. Oblique
    b. Inclined
    c. Normal

12. a, d, f, i, k, m, n

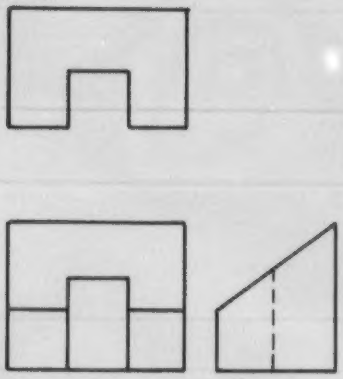
13. b, c, e, h

14. a. Phantom line (thin) c. Center line (thin)
    b. Visible line (thick) d. Hidden line (thin)

15. Intersection of fillets and rounds are used to eliminate problems in castings

16. Evaluated to the satisfaction of the instructor

17. a.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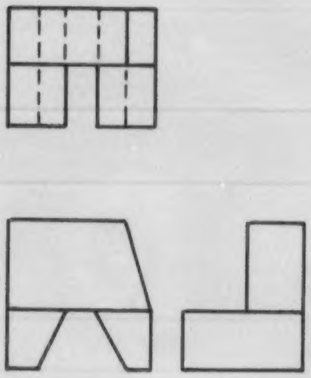
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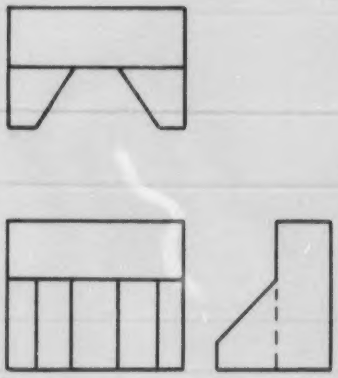
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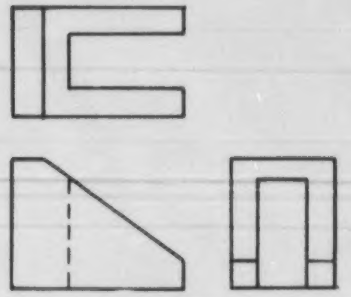
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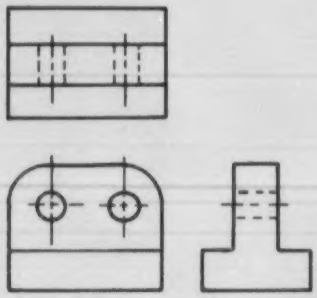
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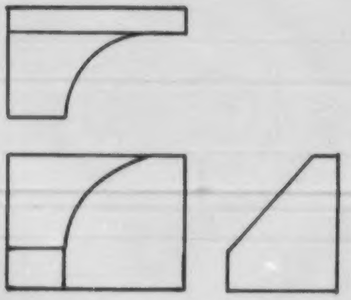
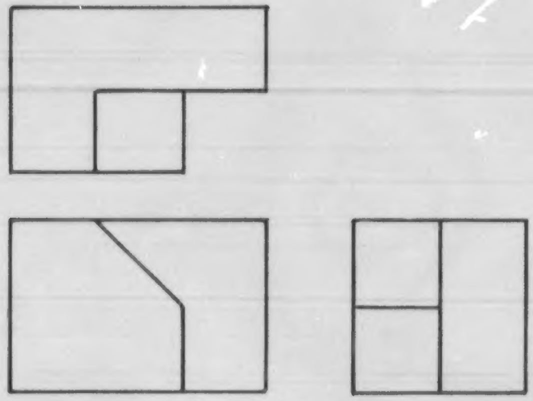
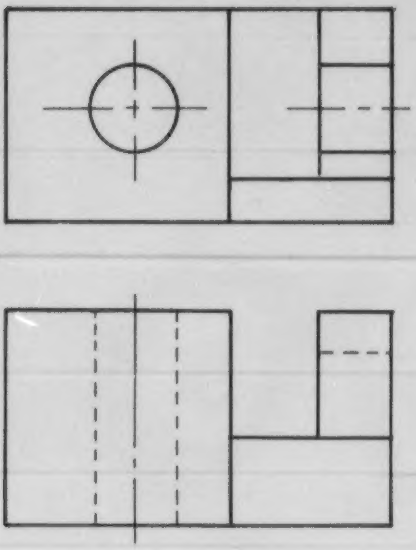

6)

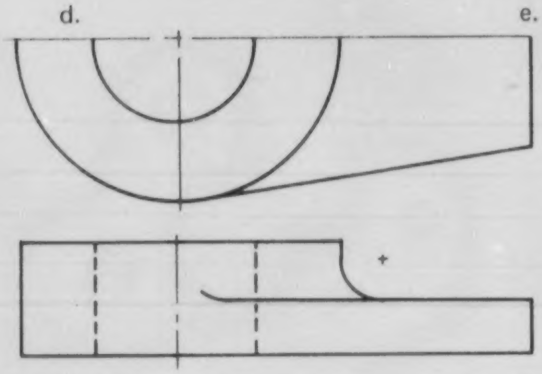
b.



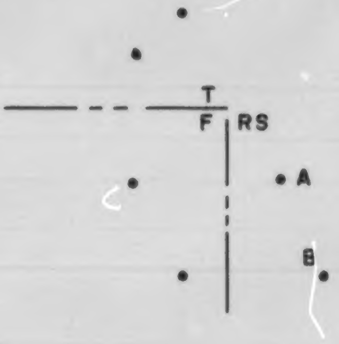
c.



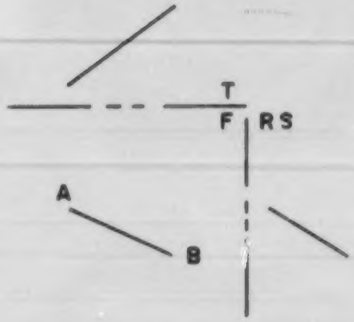
d.



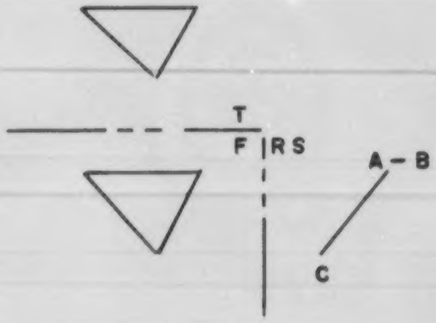
e.



f.



g.



DIMENSIONING PROCEDURES
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to relate dimensioning to correct size, shape, and location and be able to identify lines and correct line placement. The student should also be able to relate arrowheads, dual dimensions, finish marks, and mating dimensions to their purposes, and draw various illustrations that show how to properly apply the rules of dimensioning. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to dimensioning procedures with their correct definitions.
2. Distinguish between size description and shape description.
3. Differentiate between the types of dimensions.
4. Match the systems of placing dimensions with their correct definitions.
5. Match common abbreviations with their correct meanings.
6. Name and define three systems of writing dimensional values.
7. Identify four basic types of lines used in dimensioning.
8. Select true statements concerning rules for lines used in dimensioning.
9. Differentiate between correct and incorrect placement of leader lines.
10. State how to draw arrowheads.
11. List two rules concerning arrowheads.
12. Select true statements concerning rules for dimensional figures.
13. State the purpose for using dual dimensioning.
14. Match the methods of dual dimensioning with their correct definitions.
15. Select true statements concerning rules for placement of dimensions.
16. Arrange in order the steps in applying dimensions to an object.
17. State the purpose of finish marks.
18. Draw four types of finish marks.

19. Select true statements concerning rules for finish marks.
20. State the purpose for a notation on a drawing.
21. Select true statements concerning rules for notations.
22. Name and define the two types of notes used on a drawing.
23. Select true statements concerning rules for dimensioning common machine manufactured features.
24. Select true statements concerning methods of dimensioning arcs in available spaces.
25. Draw an illustration that shows how to correctly dimension angles.
26. Draw an illustration that shows how to correctly dimension curves.
27. Draw an illustration that shows how to correctly dimension rounded end shapes.
28. Draw an illustration that shows how to correctly dimension a spherical object.
29. Draw an illustration that shows how to correctly dimension cylindrical objects.
30. Draw illustrations that show how to correctly dimension cones, pyramids, and prisms.
31. Draw an illustration that shows how to correctly dimension features on a circular center line.
32. Draw an illustration that shows how to correctly dimension a theoretical point of intersection.
33. State two reasons for avoiding superfluous dimensions.
34. List ways to avoid superfluous dimensions.
35. List two factors concerning mating dimensions.
36. Draw an illustration that shows how to dimension an object using a selected coordinate system.
37. Identify various standard machine manufactured features.
38. Write proper dimension notes for standard machine manufactured features.
39. Demonstrate the ability to:
    a. Construct arrowheads.
    b. Dimension arcs.
    c. Dimension angles.
    d. Dimension curves.

e. Dimension rounded end shapes.

f. Dimension spherical objects.

g. Dimension cylindrical objects.

h. Dimension cones, pyramids, and prisms.

i. Dimension features on a circular center line.

j. Dimension a theoretical point of intersection.

k. Dimension an object using a rectangular coordinate system.

l. Dimension an object using a polar coordinate system.

m. Dimension an object using a tabular coordinate system.

n. Dimension an object using an ordinate dimensioning system.

o. Dimension an object using proper dimensioning rules and correct techniques to completely describe the object.

DIMENSIONING PROCEDURES
UNIT IV

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Arrange for the test to be presented one half at a time to facilitate its length.

VII. Have file drawings or working drawings available to demonstrate dimensioning to the class.

VIII. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objective sheet

B. Information sheet

C. Transparency masters

1. TM 1--Descriptions and Dimensions
2. TM 2-Aligned System
3. TM 3--Unidirectional System
4. TM 4--Types of Lines
5. TM 5-Rules for Lines
6. TM 6-Arrowheads
7. TM 7--Rules for Figures
8. TM 8-Staggered Numerals
9. TM 9--Dual Dimensioning Methods
10. TM 10--Placement of Dimensions

11. TM 11--Steps in Applying Dimensions
    11A--Overlay
    11B--Overlay
    11C--Overlay
    11D--Overlay
12. TM-12--Rules Pertaining to Dimensioning Common Features
13. TM 13--Dimensioning Arcs
14. TM 14--Dimensioning Angles
15. TM 15--Dimensioning Curves
16. TM 16--Dimensioning Rounded End Shapes
17. TM 17--Dimensioning Spherical Objects
18. TM 18--Dimensioning Cylindrical Objects
19. TM 19--Dimensioning Cones, Pyramids, and Prisms
20. TM 20--Dimensioning Features on a Circular Center Line
21. TM 21--Superfluous Dimensions
22. TM 22--Superfluous Dimensions (Continued)
23. TM 23--Superfluous Dimensions (Continued)
24. TM 24--Mating Dimensions
25. TM 25--Hole Operations

D. Handout 1--Abbreviations

E. Assignment sheets
1. Assignment Sheet #1--Write Proper Dimension Notes for Standard Machine Manufactured Features
2. Assignment Sheet #2--Construct Arrowheads
3. Assignment Sheet #3--Dimension Arcs
4. Assignment Sheet #4--Dimension Angles
5. Assignment Sheet #5--Dimension Curves
6. Assignment Sheet #6--Dimension Rounded End Shapes
7. Assignment Sheet #7--Dimension Spherical Objects

8. Assignment Sheet #8--Dimension Cylindrical Objects
9. Assignment Sheet #9--Dimension Cones, Pyramids, and Prisms
10. Assignment Sheet #10--Dimension Features on a Circular Center Line
11. Assignment Sheet #11--Dimension a Theoretical Point of Intersection
12. Assignment Sheet #12--Dimension an Object Using a Rectangular Coordinate System
13. Assignment Sheet #13--Dimension an Object Using a Polar Coordinate System
14. Assignment Sheet #14--Dimension an Object Using a Tabular Coordinate System
15. Assignment Sheet #15--Dimension an Object Using an Ordinate Dimensioning System
16. Assignment-Sheet #16--Dimension an Object Using Proper Dimensioning Rules and Correct Techniques to Completely Describe the Object

F. Test

G. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

B. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing.* New York 10022: Macmillan Publishing Co., 1968.

C. Giesecke, Frederick E., et al. *Technical Drawing.* New York: Macmillan Publishing Co., Inc., 1980.

D. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

III. Additional reference--Oberg, Erik and F. D. Jones. *Machinery's Handbook.* New York, NY 10016: Industrial Press, Inc., 1978.

DIMENSIONING PROCEDURES
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Superfluous--Exceeding what is sufficient or necessary

B. Datum--Points, lines, or other geometric shapes assumed to be exact from which the location or geometric features of a part may be established

C. Tabular--Set up in rows and columns, by means of a table

D. Reference dimension--A dimension used for information purposes only; it does not govern production or inspection operations

E. Actual size--Measured size of a complete object

F. Finish mark--A symbol used to indicate a surface to be machined

G. Taper--A gradual decrease or change of diameter from one end to the other

H. Bevel--A slanted flat surface not at 90° to another surface

I. Chamfer--A slight bevel removed from an edge

J. Drill--A tool with a pointed cutting edge used to make a hole in hard surfaces

K. Bore--To enlarge a hole with a boring bar or tool in a lathe, drill press, or boring mill

L. Ream--To enlarge a finished hole slightly to a very precise diameter with a reamer

M. Counterdrill--A second, larger drill along the same center line as a first drill, but not as deep

N. Countersink--A funnel-like bevel at the surface end of a drilled hole; standard included angle is 82°

O. Counterbore--An enlargement of the end of a hole to a specified diameter and depth

P. Spot face--A machined circular spot on the surface of a part to provide a flat bearing surface for a bolt head

Q. Knurl--The process of rolling depressions in the surface of an object

R. Relief groove--A shallow groove that allows for a thread relief

S. Blind hole--A hole not drilled all the way through

INFORMATION SHEET

T. Tap--A tool used to cut internal threads

U. Die--A tool used to cut external threads

V. Boss--A raised flat, cylindrical surface providing a flat surface for bolts

W. Radial--Moving along a radius

X. Nominal--Designated or theoretical size that may vary from the actual

II. Size and shape description (Transparency 1)

A. Size description--The notes and dimensions that tell the size of an object

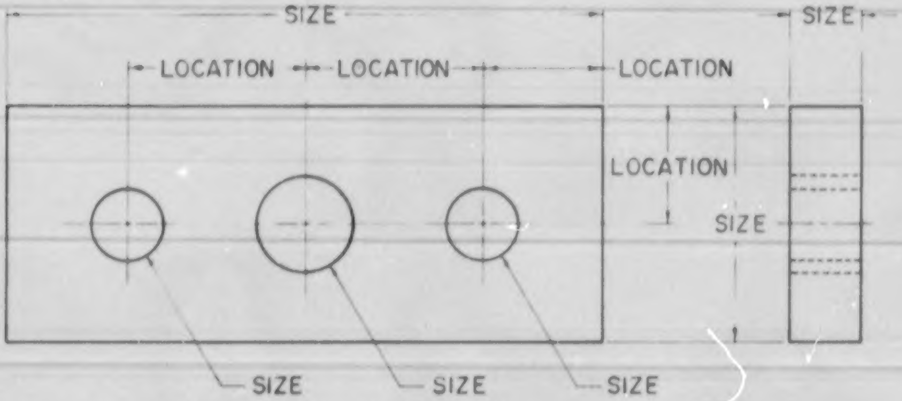
B. Shape description--The views that illustrate the shape of an object

III. Types of dimensions (Transparency 1)

A. Size dimension--Any type of dimension that tells how large or small an object is

B. Location dimension--Any type of dimension that locates a feature on an object

Example:



IV. Systems of placing dimensions and definitions

A. Aligned system--All dimension figures are aligned with the dimension lines so that they may be read from the bottom or from the right side of the sheet (Transparency 2)

(NOTE: Dimensions and notes shown with leader lines are aligned with the bottom of the page.)

INFORMATION SHEET

B. Unidirectional system--All dimension figures and notes are lettered horizontally on the sheet and read from the bottom of the drawing (Transparency 3)

(NOTE: Never letter dimensions or notes in either system to read from the left of the sheet.)

V. Common abbreviations and meanings (Handout 1)

A. ANSI--American National Standards Institute

B. ASSY--Assembly

C. BEV--Bevel

D. B/M--Bill of materials

E. BC--Bolt circle

F. CI--Cast iron

G. CS--Cast steel

H. CL--Center line

I. C to C--Center to center

J. CHAM--Chamfer

K. CRS--Cold rolled steel

L. CBORE--Counterbore

M. CDRILL--Counterdrill

N. CSK--Countersink

O. DEG--Degree

P. DIA--Diameter

Q. DIM.--Dimension

R. DWG--Drawing

S. FAO--Finish all over

T. ID--Inside diameter

U. KST--Keyseat

V. KWY--Keyway

W. LH--Left hand

INFORMATION SHEET

X. MATL--Material

Y. MIL-STD--Military standard

Z. OD--Outside diameter

AA. R--Radius

BB. SAE--Society of Automotive Engineers

CC. SF--Spot faced

DD. THD--Thread

EE. TOL--Tolerance

(NOTE: Refer to Handout 1 or ANSI Y1.1-1972 for other standard abbreviations.)

VI. Systems of writing dimensional values and their definitions

A. Fractional--System of units and common fractions used primarily in structural work

B. Decimal--System of units and decimals used in machine drawing where extreme accuracy is required

(NOTE: The decimal system is compatible with the calibrations of machine tool controls and numerically controlled machine tools.)

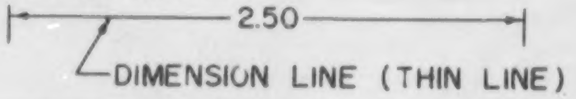
C. Metric--System of units and decimals based on "The International System of Units", where the millimeter is the linear unit of measure

(NOTE: Industry is moving rather rapidly to conform with this universal system. Many companies are requiring drawings to be dual dimensioned in millimeters and decimal inches.)

VII. Basic types of lines used in dimensioning (Transparency 4)

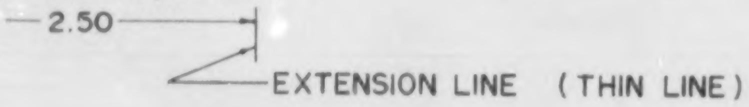
A. Dimension line--A line, with arrowheads, that shows the direction and length of what is being measured

Example:



B. Extension line--A line used to indicate the extension of a surface or a point to a location outside the part outline

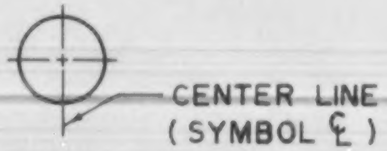
Example:



INFORMATION SHEET

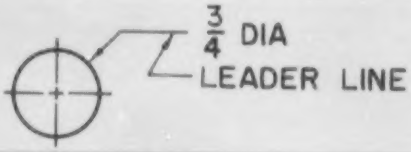
C. Center line--A line used to indicate the center of a cylindrical feature

Example:



D. Leader line--A thin solid line that "leads" from a note or dimension and is terminated by an arrowhead touching the part to which attention is directed

Example:



VIII. Rules for lines used in dimensioning (Transparency 5)

A. Extension lines show what is to be measured

B. Extension lines show the location of other details

C. Extension lines start or stop 1/16" away from visible lines and are extended approximately 1/8" beyond dimension lines

D. Extension lines may cross each other or visible lines without a break

E. Extension lines are classified as thin lines

F. Extension lines may cross each other but they can never cross dimension lines

G. Center lines may be used as extension lines but never as dimension lines

H. Dimension lines should not be less than .40" away from visible lines or .24" away from each other

(NOTE: Refer to ANSI Y14.5-1973.)

I. Dimension lines are classified as thin lines

J. Dimension lines are broken to allow space for the dimension

K. Keep dimensions in line

L. Dimension lines are drawn as arcs to show angular measurement

INFORMATION SHEET

M. Leaders are usually drawn at a 45°, 30°, or 60° angle to the horizontal, but never vertical or horizontal

N. The leader arrowhead touches the arc and points toward the center point

O. The leader arrow is placed on the outside of small arcs and on the inside of larger arcs

P. A horizontal "shoulder" approximately 1/8" long should extend from end of leader

Q. Leaders should extend past the visible lines to keep the dimensions of notes off the object; leaders and notes should be added last so that a neat drawing will result

R. A leader always points toward the center of a circle, but it stops at the circumference of the circle

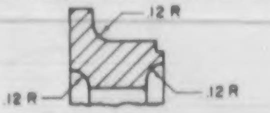
S. A leader should always point to the beginning or the end of a note

T. Normally, a leader terminates in an arrowhead; however, where it is intended for a leader to make reference to a surface by ending within the outline of that surface, the leader should terminate in a dot

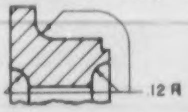
IX. Correct and incorrect placement of leader lines

A. Dimensions are specified individually to avoid complicated leaders

Example:



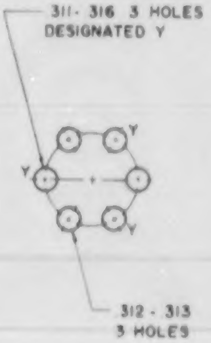
Recommended



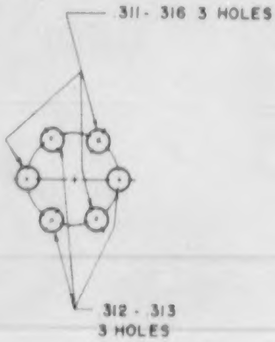
Not recommended

B. If too many leaders would impair the legibility of the drawing, letter symbols should be used to identify features

Example:



Recommended

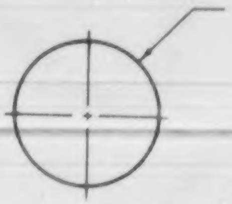


Not recommended

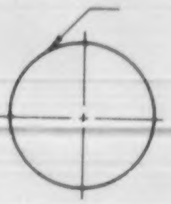
INFORMATION SHEET

C. Where a leader is directed to a circle or arc, its direction should be toward the center

Example:



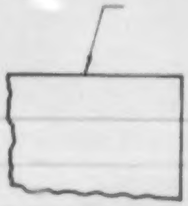
Recommended



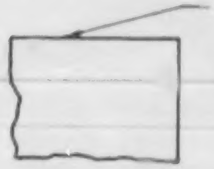
Not recommended

D. Avoid small angles between leaders and the lines where they terminate

Example:



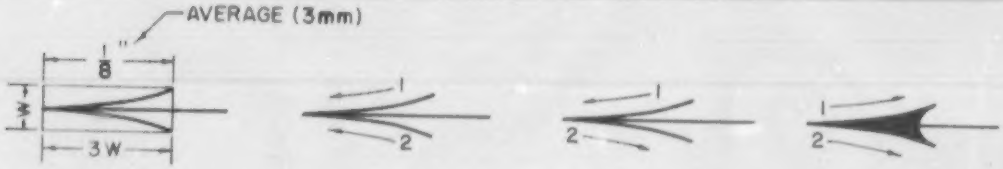
Recommended



Not recommended

X. How to draw arrowheads--Arrowheads are drawn with two sharp strokes toward or away from the point; length will vary depending on size of drawing, but width should always be 1/3 of the length (Transparency 6)

Example:



XI. Rules concerning arrowheads (Transparency 6)

A. Arrowheads always touch extension lines

B. Arrowheads are reversed when space for the dimension is too small

XII. Rules for dimensional figures (Transparency 7)

A. All lettering, letters, and numerals must be perfectly legible

B. Numerals should be large enough to be easily read; standard height is 1/8"

C. Fractions are two times the height of whole numbers

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D. Inch marks (") are omitted unless a dimension may be misunderstood; thus, 1" DRILL should be written 1 DRILL

E. The fraction bar is always in line with the dimension line; the fraction bar is never drawn at an angle

(NOTE: An exception to this may be made in crowded places, such as parts lists, but never in dimensioning on a view.)

F. The numerator and denominator of a fraction should never touch the fraction bar

G. Never letter a dimension figure over any line on the drawing; break the line if necessary

H. Make all decimal points bold

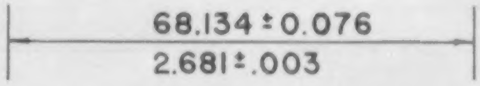
I. In a group of parallel dimension lines, the numerals should be staggered, not stacked one above the other (Transparency 8)

XIII. Purpose for using dual dimensioning–To show dimensions in millimeters and inches; it is especially applicable to the manufacture of interchangeable parts on an international basis

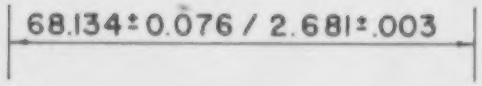
XIV. Three methods of dual dimensioning (Transparency 9)

A. Position method–The millimeter value is placed above the inch dimension and separated by a dimension line (A), or an alternative arrangement is to place the millimeter dimension to the left of the inch dimension separated by a slash (B)

Examples:



(a)



(b)

(NOTE: Placement of the inch dimension above or to the left of the millimeter is not acceptable.)

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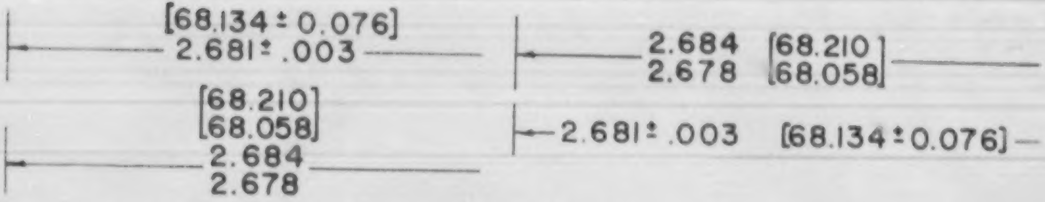
B. Bracket method–The millimeter dimension is enclosed in square brackets, and the location of this dimension is optional, but should be uniform on any drawing

Examples:



(NOTE: Drawing should include a note to identify the dimension value in the brackets.)

Example: NOTE: All dimensions in [ ] are millimeters.

C. Chart method–One dimension value is given for each dimension on the drawing, and elsewhere on the drawing a conversion table lists in two columns the millimeter values and the inch equivalents

CONVERSION CHART

mm	(inch)	mm	(inch)	mm	(inch)	mm	(inch)
0.025	.0010	6.6	.26	18.44	.726	43.7	1.72
0.038	.0015	7.1	.28	28.70	1.130	45.62	1.796
0.064	.0025	7.92	.312	28.83	1.135	45.77	1.802
0.076	.0030	8.13	.320	29.08	1.145	50.67	1.995
0.102	.0040	10.03	.395	29.21	1.150	50.80	2.000
0.127	.0050	10.29	.405	34.5	1.36	63.5	2.50
0.25	.010	10.7	.42	35.6	1.400	85.72	3.375
0.75	.030	10.9	.43	43.2	1.70	101.6	4.00
3.0	.12	18.29	.720				

XV. Rules for placement of dimensions (Transparency 10)

A. Each dimension should be given clearly so that it can be interpreted in only one way

B. Dimensions should not be duplicated or the same information be given in two different ways, dual dimensioning excluded, and no dimensions should be given except those needed to produce or inspect the part

C. Dimensions should be given between points or surfaces that have a functional relation to each other or that control the location of mating parts

D. Dimensions should be given to finished surfaces or important center lines in preference to rough surfaces wherever possible

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E. Dimensions should be so given that it will not be necessary for the machinist to calculate, scale, or assume any dimension

F. Dimensions should be attached to the view where the shape is best shown (contour rule)

G. Dimensions should be placed in the views where the features dimensioned are shown true shape

H. Avoid dimensioning to hidden lines wherever possible

I. Dimensions should not be placed upon a view unless clearness is promoted and long extension lines are avoided

J. Dimensions applying to two adjacent views should be placed between views unless clearness is promoted by placing some of them outside

K. The longer dimensions should be placed outside all intermediate dimensions so that dimension lines will not cross extension lines

L. Do not expect the worker to assume that a feature is centered (as a hole on a plate), but give a location dimension from one side

M. Horizontal and vertical center lines may be used as reference (base) lines for dimensions

XVI. Steps in applying dimensions to an object (Transparency 11)

A. Draw extension lines and extend the center lines of the hole to be used in the same manner as extension lines (Overlay 11A)

B. Use scale to measure dimension line locations with adequate space betweer each and gaps for dimension figures (Overlay 11B)

C. Draw in arrowheads (Overlay 11C)

D. Draw in guidelines for figures

E. Letter in dimensions (Overlay 11D)

XVII. Purpose of finish marks--To indicate a surface on an object that is to be finished or machined

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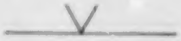
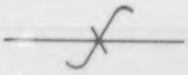
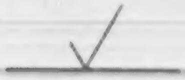
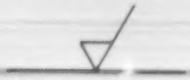
XVIII. Four types of finish marks

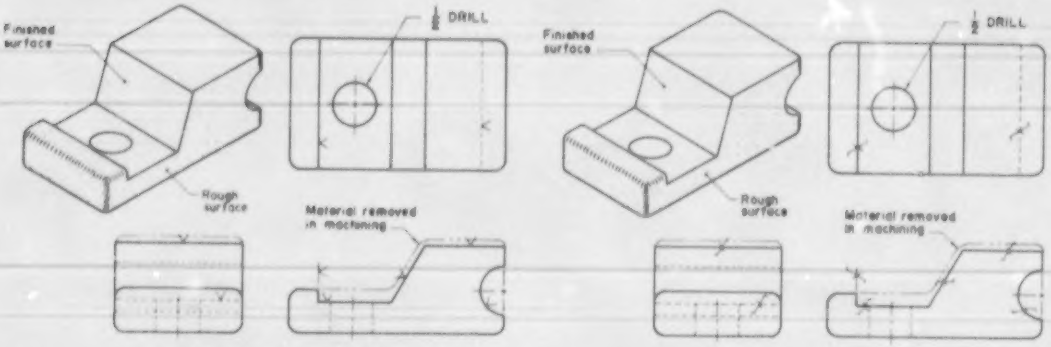
A. 

B. 

C. 

D. 

Examples:


Finished surface
1/2 DRILL
Rough surface
Material removed in machining
Finished surface
1/2 DRILL
Rough surface
Material removed in machining

XIX. Rules for finish marks

A. Finish marks should be placed on the edge views of all finished surfaces, including hidden edges and the contour and circular views of cylindrical surfaces

B. Finish marks should be omitted on holes or other features where a note specifies a machining operation

C. Finish marks should be omitted on parts made from rolled stock

D. If a part is finished all over, omit all finish marks, and use the following general note: FINISH ALL OVER, or FAO

XX. Purpose for a notation on a drawing--To provide in concisely worded statements information that cannot be given by standard dimensions

XXI. Rules for notations

A. Notes are always placed parallel to the bottom of the drawing

B. Notes should be brief and clear and contain only pertinent data

C. Notes should be spaced far enough from the views not to crowd, but still close enough to eliminate the need for a long leader

D. Notes should always be composed so that the various shop operations are listed in the order in which they should be performed

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E. Use upper case letters for all notes on machine drawings

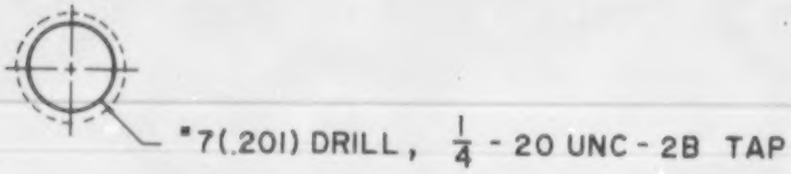
XXII. Two types of notes used on a drawing and their definitions

A. General note–Consists of information which applies to the entire drawing

Example: All fillets and rounds 1/8 R unless otherwise specified

B. Local (specific) note–Refers to one particular feature and requires the use of a leader

Example:



XXIII. Rules for dimensioning common machine manufactured features (Transparency 12)

A. "R" follows all radii dimensions; the center is shown by a cross and only one arrowhead is used; available space determines whether the dimension figure goes inside or outside the arc

B. In general, a circle is dimensioned by its diameter, an arc by its radius

C. Avoid diagonal diameters, except for very large holes and for circles of centers; they may be used on positive cylinders when clearness is gained thereby

D. A metric diameter dimension value should be preceded by the symbol Ø and the diameter dimension value in inches should be followed by DIA except when either dimension is obviously a diameter

E. The letter R should always follow a radius dimension figure; the radial dimension line should have only one arrowhead, and it should pass through or point through the arc center and touch the arc

F. Cylinders should be located by their center lines

G. Drill sizes are preferably expressed in decimals; for drills designated by number or letter, the decimal size must also be given

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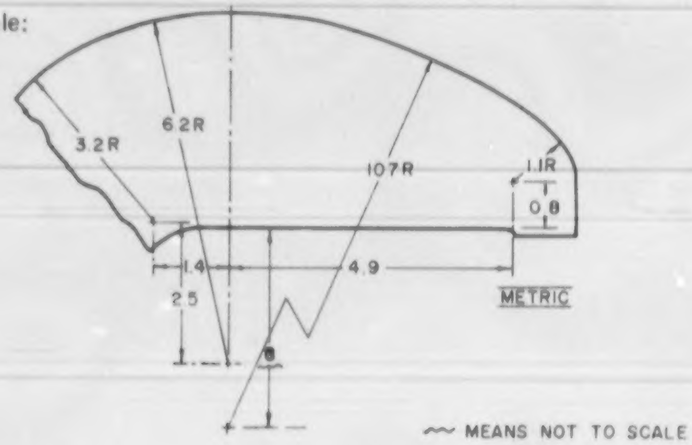
H. Cylinders should be located in the circular views, if possible

I. Cylinders should be located by coordinate dimensions in preference to angular dimensions where accuracy is important

J. When there are several rough noncritical features obviously the same size such as fillets or rounds, it is necessary to give only typical dimensions, or to use a note

K. When a dimension is not to scale, it should be underscored with a wavy line or marked NTS or NOT TO SCALE

Example:



L. Mating dimensions should be given respondingly on drawings of mating parts

M. Pattern dimensions should be given in two-place decimals or in common whole numbers and fractions to the nearest 1/16"

N. Decimal dimensions should be used when accuracy greater than 1/64" is required on a machine dimension

XXIV. Methods of dimensioning arcs in available spaces (Transparency 13)

A. An arc is dimensioned in the view in which its true shape is shown

B. The center should be indicated by a small cross to locate exact center point

(NOTE: Center cross should be omitted for small or unimportant radii.)

C. In least limited space, keep figure and arrowhead inside

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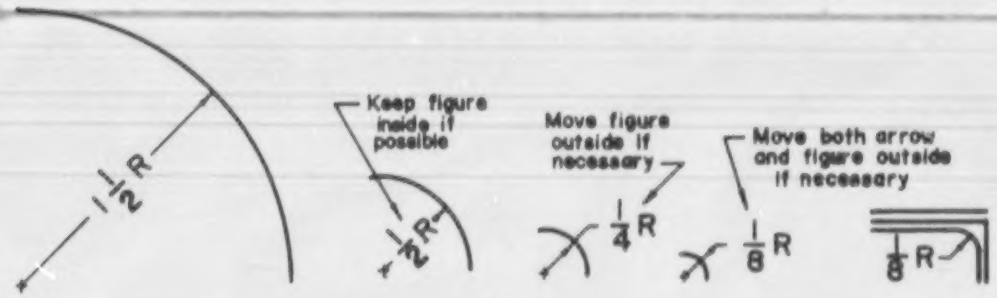
D. In limited space, move figure outside

E. In most limited space, move figure and arrowhead outside

Example:

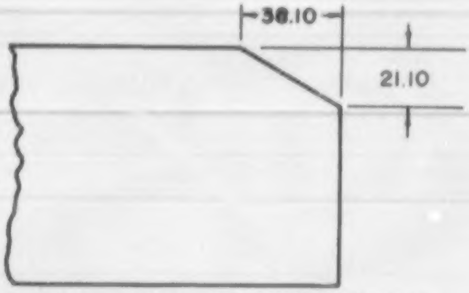

1 1/2 R
Keep figure inside if possible
1/2 R
Move figure outside if necessary
1/4 R
Move both arrow and figure outside if necessary
1/8 R
1/8 R

XXV. How to correctly dimension angles (Transparency 14)

A. By means of coordinate dimensions of the two legs of a right triangle

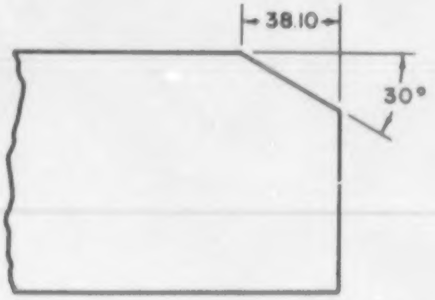
(NOTE: Coordinate dimensions are preferred when a high degree of accuracy is required.)

Example:



B. By means of a linear dimension and an angle in degrees

Example:



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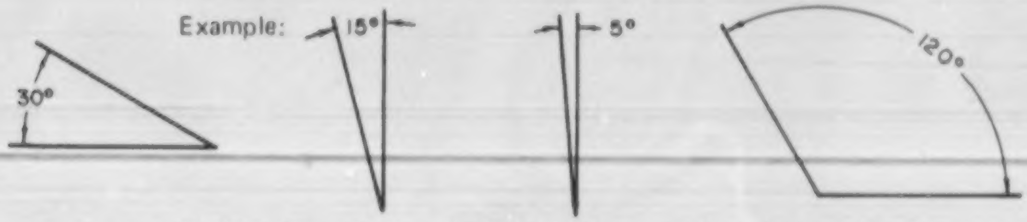
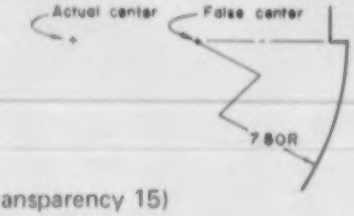
C. Variations of degrees and arrowhead placement should be as follows:

Example:



(NOTE: The circular dimension lines are always drawn with the compass center at the vertex of the angle.)

D. For a long radius with center point outside available space, the dimension leader is drawn toward the actual center, but a false center is indicated and the dimension line is jogged to it

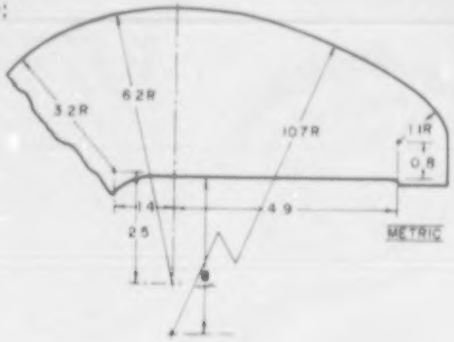


XXVI. How to correctly dimension curves (Transparency 15)

A. Continuous curves made up of a series of circular arcs with known center points

1. Dimension all arcs with leader lines
2. Locate all center points from each other and from some common datum point

Example:



(NOTE: For extremely large radii, such as the 12 1/2" radius in the example above. The center may be drawn closer to the arc than actual size; the actual location dimension is still given even though it is not to scale.)

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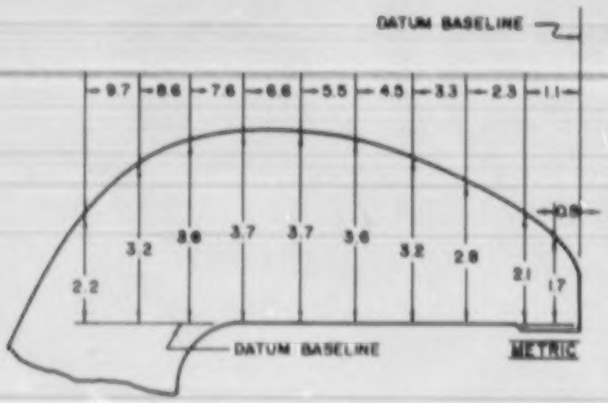
B. Irregular curves with unknown center points can be dimensioned by means of coordinate dimensions or from two datum base lines, a method which will provide a series of points which can be connected with an irregular curve

Example:


DATUM BASELINE
9.7
8.6
7.6
6.6
5.5
4.5
3.3
2.3
1.1
0.5
2.2
3.2
3.6
3.7
3.7
3.6
3.2
2.8
2.1
1.7
DATUM BASELINE
METRIC

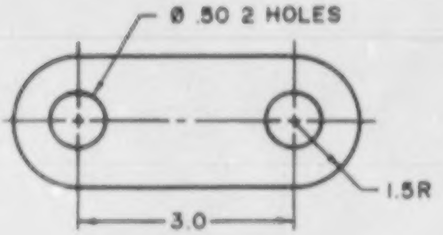
(NOTE: Values in upper line in example are not accumulative, yet they are all in one line.)

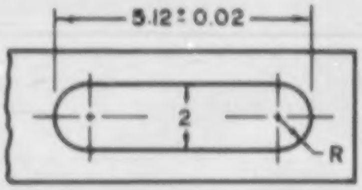
XXVII. How to correctly dimension rounded end shapes (Transparency 16)

A. By giving C to C dimension and radius of rounded end

(NOTE: This method is used when precision is not necessary.)

Example:


Ø .50 2 HOLES
1.5R
3.0



B. By giving overall dimension and diameter of feature

(NOTE: This method is used when precision is required.)

XXVIII. How to correctly dimension a spherical object (Transparency 17)

A. A spherical end is dimensioned by a radius, followed by "SPHER R" (example a)

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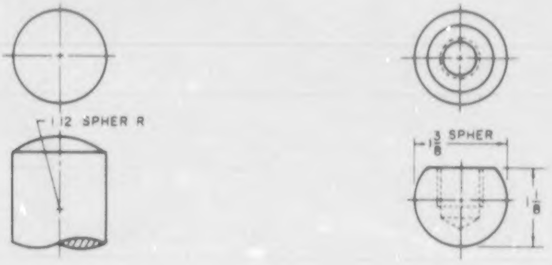
B. A sphere is dimensioned by giving its diameter (example b)

Examples:

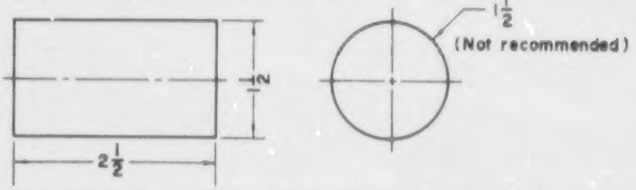

1 1/2 SPHER R
$1\frac{3}{8}$ SPHER
$1\frac{1}{8}$

(a) (b)

XXIX. How to correctly dimension cylindrical objects--give both the diameter and the length in the rectangular view (Transparency 18)

(NOTE: The radius of a cylinder should never be given.)

Example:

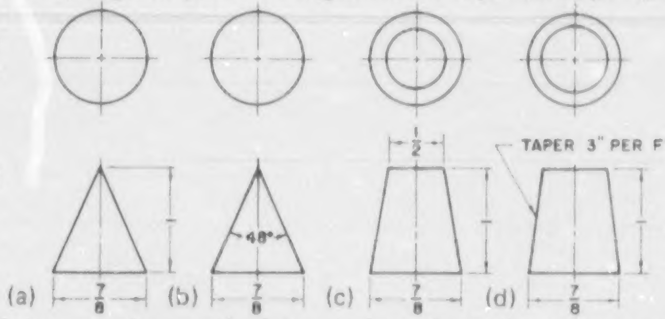

$\frac{1}{2}$
$2\frac{1}{2}$
$1\frac{1}{2}$
(Not recommended)

XXX. How to correctly dimension cones, pyramids, and prisms (Transparency 19)

A. Cones

1. Diameter and height in the triangular view (example a)
2. Diameter and the angle (example b)
3. Give two diameters and the height (example c)
4. Diameter of large end, and the height and the taper (example d)

Examples:


$\frac{1}{2}$
TAPER 3" PER FT
48°
(a) $\frac{7}{8}$
(b) $\frac{7}{8}$
(c) $\frac{7}{8}$
(d) $\frac{7}{8}$

(NOTE: The appropriate method to use depends on the accuracy required and the process that will be used to make the cone.)

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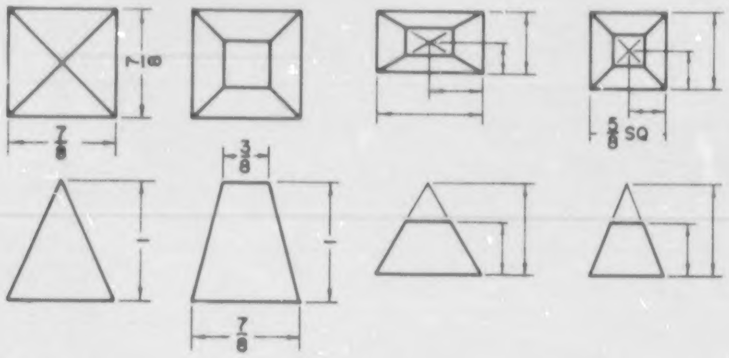
B. Pyramids

1. Give dimensions of base in rectangular view and the height in the other view (example a)

2. Give dimensions of base and locate center point in rectangular view and give height in the other view (example b)

Examples:



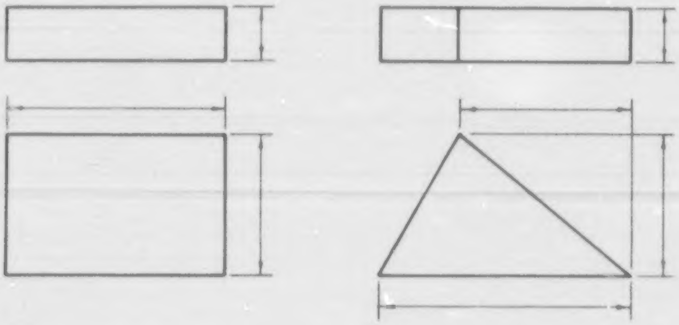
(a) (b) (c) (d)

C. Prisms

1. Give the height, width, and depth

2. Two of the dimensions will be in one view and the third dimension will always be in the next view

Examples:



(a) (b)

XXXI. How to correctly dimension features on a circular center line (Transparency 20)

A. Holes equally spaced are dimensioned by giving the diameter of the center line or bolt circle and specifying "equally spaced" in a note (example a)

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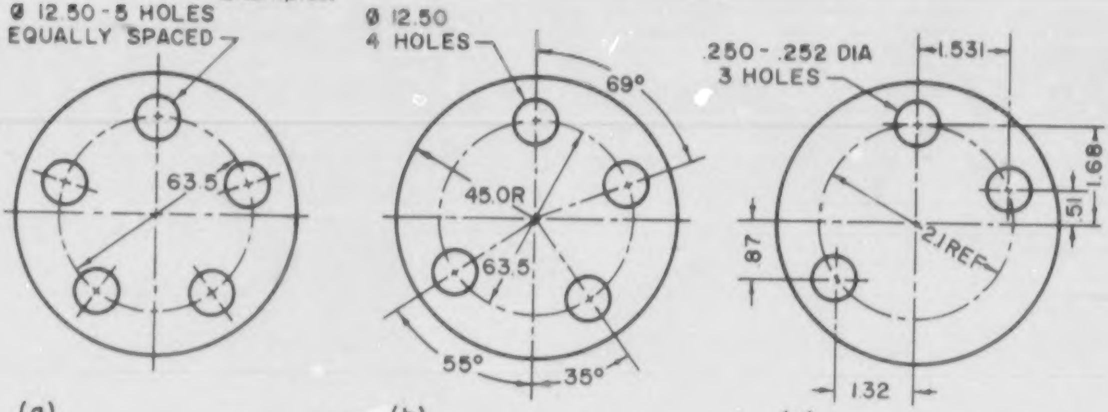
B. Holes unequally spaced are dimensioned by giving the diameter of the center line plus angular measurements with reference to one of the center lines (example b)

C. When precise accuracy is required, coordinate dimensions should be given using the center lines as datum lines (example c)

(NOTE: Circular center line will be marked "REF" to indicate that it is to be used only as a reference line.)

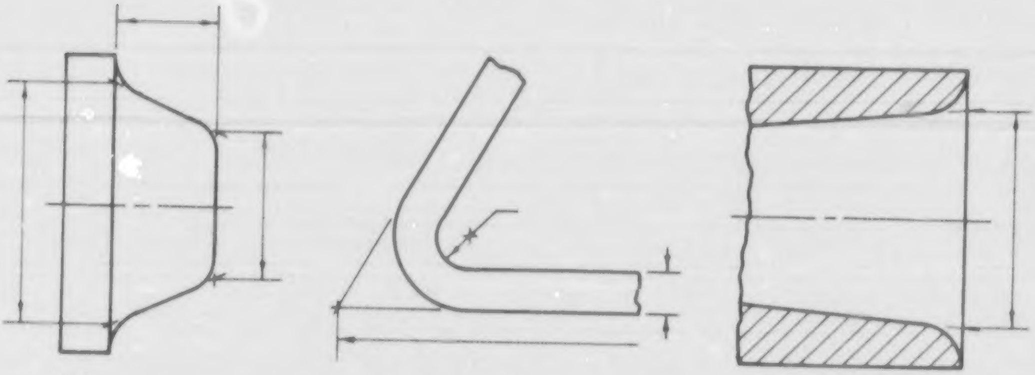
Examples:


Ø 12.50 - 5 HOLES
EQUALLY SPACED
63.5
Ø 12.50
4 HOLES
69°
45.0R
63.5
55°
35°
.250 - .252 DIA
3 HOLES
1.531
1.68
.51
.87
2.1 REF
1.32

(a) (b) (c)

METRIC

XXXII. How to correctly dimension a theoretical point of intersection--Project extension lines until they cross, forming a point that can be dimensioned



(a) (b) (c)

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XXXIII. Reasons for avoiding superfluous dimensions

A. Duplication of effort (wasted time)

B. Increased chance of error for drafter and workers

XXXIV. How to avoid superfluous dimensions (Transparencies 21, 22, and 23)

A. Give dimensions in the most direct and simple way

B Always dimension to shop operation requirements

C. Never give a dimension more than once in the same view or in different views

D. Remember that the worker should never have to do any calculations from a drawing to find a necessary dimension

XXXV. Factors concerning mating dimensions (Transparency 24)

A. On two mating parts certain dimensions must correspond to make the parts fit together; these are mating dimensions

B. While the base size will remain the same, the actual values of two corresponding mating dimensions may not be exactly the same because the difference will depend on the accuracy of fit required

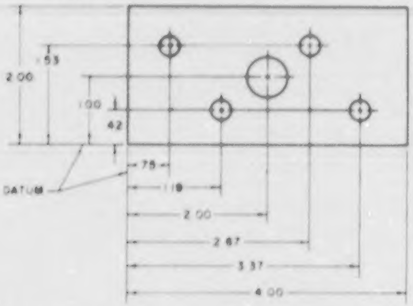
XXXVI. How to dimension an object using coordinate dimension systems

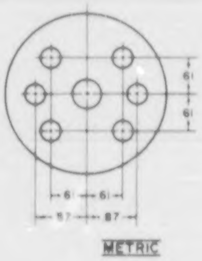
A. Rectangular coordinate system

1. All horizontal dimensions are from a common datum line

2. All vertical dimensions are from a common datum line

Examples:





(NOTE: This method is used to draw parts that are to be numerically machined.)

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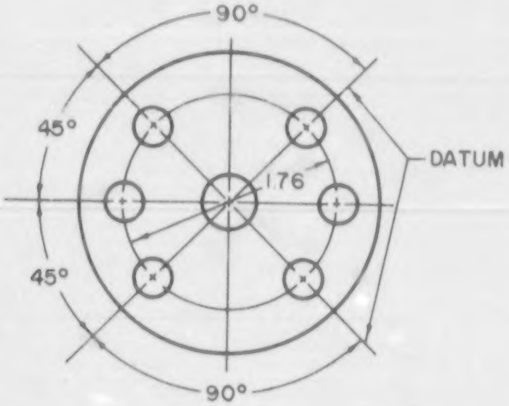
B. Polar coordinate system

(NOTE: This is used when holes or other features to be located lie in a circular or radial pattern.)

1. Give a radial dimension from the center of the pattern in the form of a diameter

2. Give angular dimensions from a datum

Example:

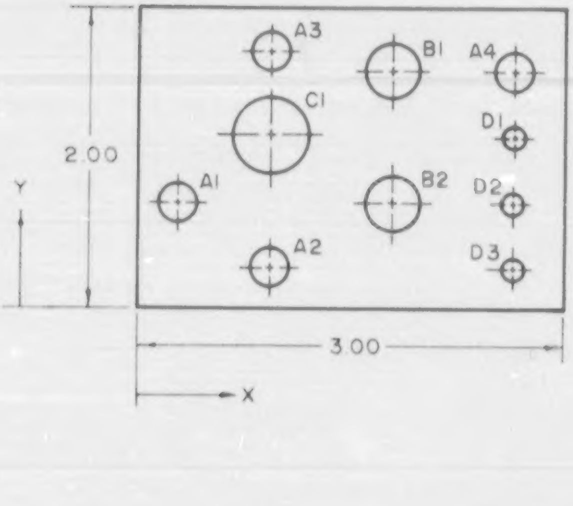


C. Tabular coordinate system

1. Dimension placement is the same as for rectangular coordinate dimensioning, using horizontal and vertical datum planes

2. Dimension figures are not applied directly to the views but are placed in a table and the holes are labeled with a code letter

Examples:



	REQ'D	4	2	1	3
	HOLE DIA.	.250	.312	.500	.125
POSITION		HOLE SYMBOL			
X →	Y ↓	A	B	C	D
.250	.625	A1			
1.000	.250	A2			
1.000	1.750	A3			
2.750	1.500	A4			
1.750	1.500		B1		
1.750	.625		B2		
1.000	1.000			C1	
2.750	1.000				D1
2.750	.625				D2
2.750	.250				D3

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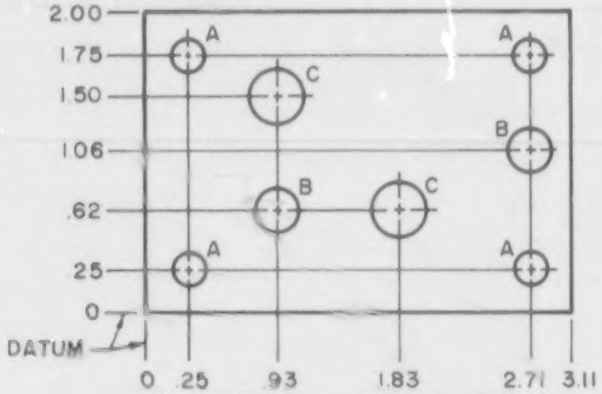
D. Ordinate dimensioning

(NOTE: Other names for this system are zero plane or arrowless.)

1. Dimension placement is the same as for rectangular coordinate in that it uses perpendicular datum planes
2. The datum planes are indicated as zero coordinates
3. Dimensions from these planes are shown on extension lines without the use of dimension lines or arrowheads



SIZE SYMBOL	A	B	C
HOLE DIA	.250	.312	.375

XXXVII. Various standard machine manufactured features

A. Hole operations (Transparency 25)

1. Drill, bore, ream
2. Counterdrill
3. Countersink

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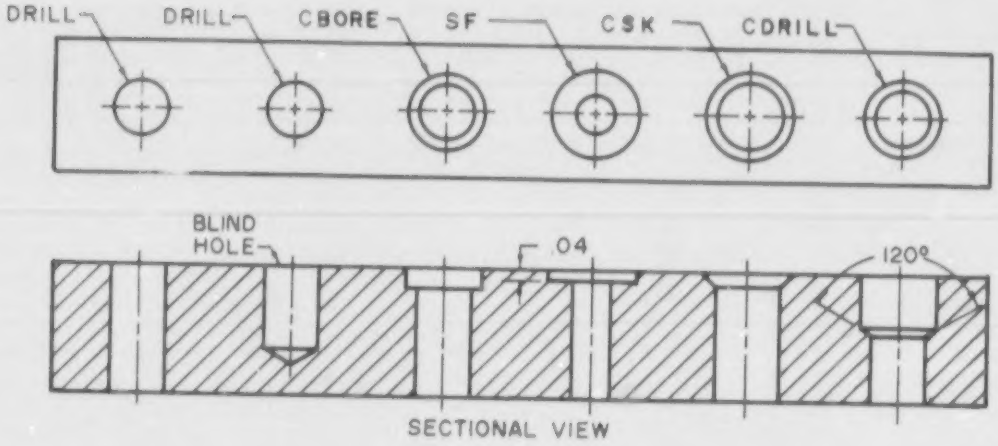
4. Counterbore

5. Spot faced

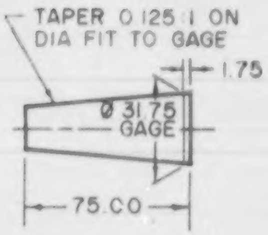
(NOTE: Refer to terms and definitions for descriptions.)

Examples:

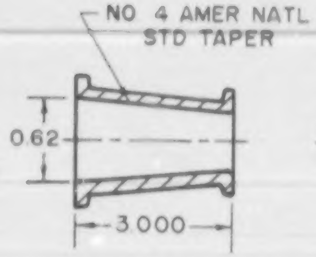

DRILL
DRILL
CBORE
SF
CSK
CDRILL
BLIND HOLE
.04
120°
SECTIONAL VIEW

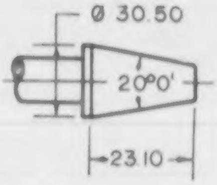
B. Taper

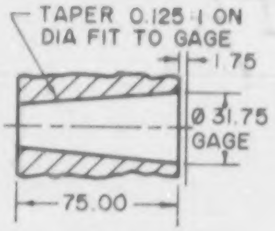
Examples:


TAPER 0.125:1 ON DIA FIT TO GAGE
1.75
Ø 31.75 GAGE
75.C0

METRIC


NO 4 AMER NATL STD TAPER
0.62
3.000


Ø 30.50
20°0'
23.10

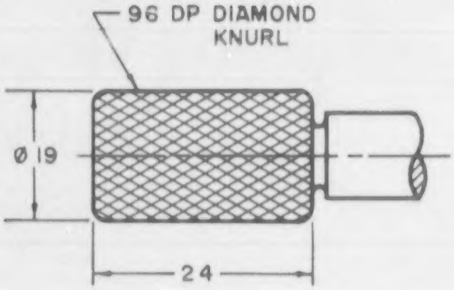

TAPER 0.125:1 ON DIA FIT TO GAGE
1.75
Ø 31.75 GAGE
75.00

INFORMATION SHEET

C. Knurl

1. Diamond pattern

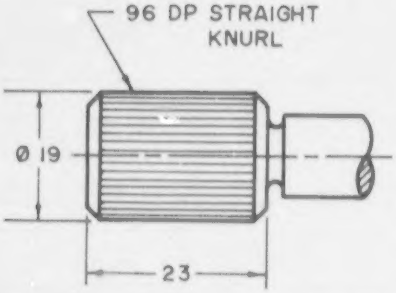
   Example:


96 DP DIAMOND KNURL
Ø 19
24

METRIC

2. Straight line

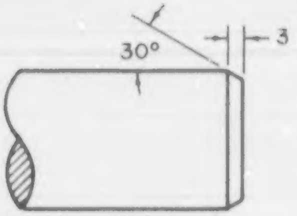
   Example:

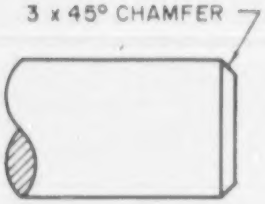

96 DP STRAIGHT KNURL
Ø 19
23

METRIC

D. Chamfers:

Examples:




3 x 45° CHAMFER

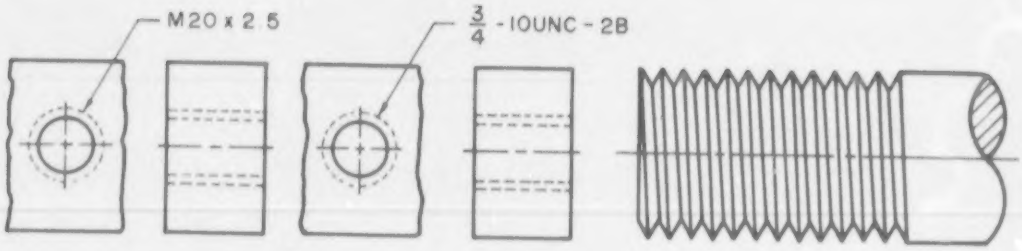
METRIC

INFORMATION SHEET

E. Threads

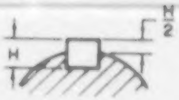
1. Internal
2. External

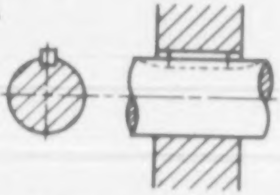
Examples:

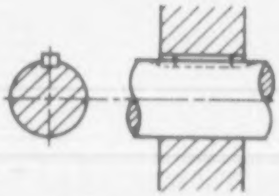

M20 x 2.5
$\frac{3}{4}$ - 10UNC - 2B

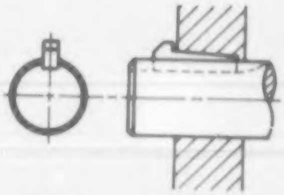
F. Keyways and keyseats

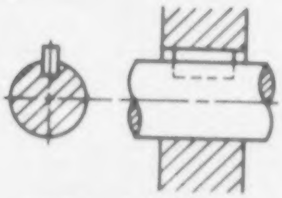
1. Square
2. Flat
3. Gib head
4. Pratt and Whitney
5. Woodruff

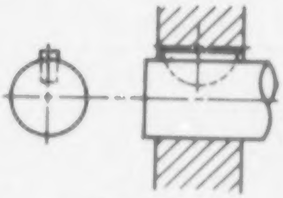



(1) SQUARE KEY


(2) FLAT KEY


(3) GIB HEAD KEY

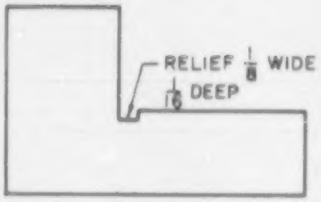

(4) PRATT & WHITNEY KEY


(5) WOODRUFF

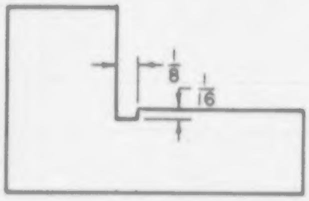
INFORMATION SHEET

G. Relief groove

Examples:


RELIEF $\frac{1}{8}$ WIDE
$\frac{1}{16}$ DEEP

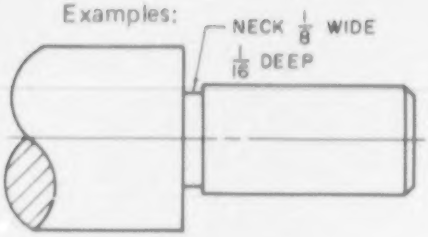
USING A NOTE


$\frac{1}{8}$
$\frac{1}{16}$

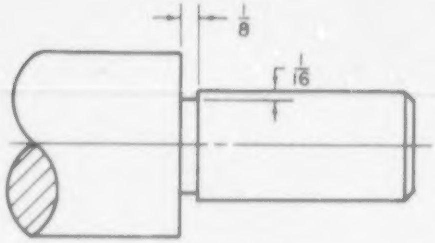
USING DIMENSIONS

H. Neck

Examples:


NECK $\frac{1}{8}$ WIDE
$\frac{1}{16}$ DEEP

USING A NOTE


$\frac{1}{8}$
$\frac{1}{16}$

USING DIMENSIONS

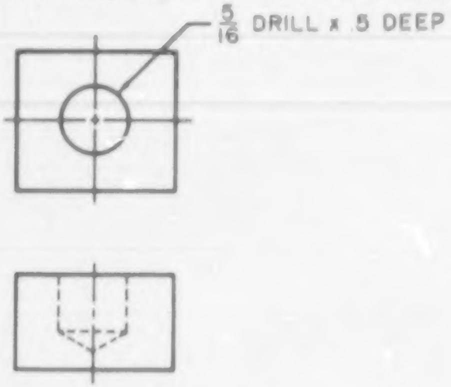
XXXVIII. Proper dimension notes for standard machine manufactured features

A. Hole operations--Holes are always dimensioned on the view in which they appear as a circle

1. Drill--Hole sizes are always specified by diameter, never by radius; the diameter is given in a common fraction or in decimal form and the word drill follows the size

(NOTE: For drills designated by number or letter, the decimal size must be given.)

Examples:

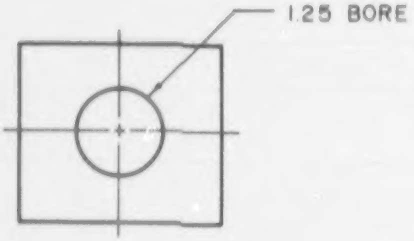

$\frac{5}{16}$ DRILL x .5 DEEP

(NOTE: A drill that does not go all the way through is a blind drill and depth must be included.)

INFORMATION SHEET

2. Bore--Hole diameter is specified in decimal form and the word bore follows the size

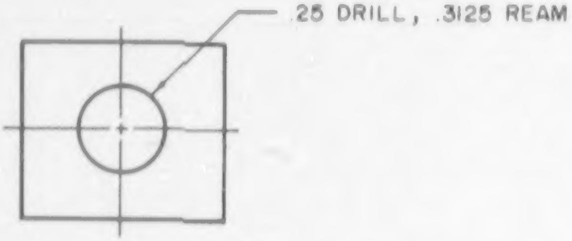
Example:



(NOTE: A bore is a more precise method of obtaining a diameter than a drill but not as precise as a ream.)

3. Ream--Predrill size is specified first, then the ream size in decimal form followed by the word ream is applied to view in form of a note

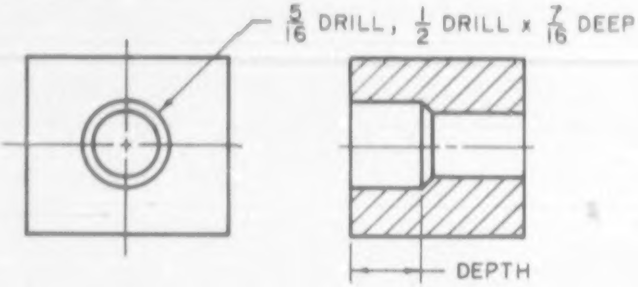
Example:


.25 DRILL, .3125 REAM

(NOTE: A ream is the most precise method of obtaining an accurate diameter.)

B. Counterdrill--Diameter of first drill is given first, then the diameter of the second drill by the depth

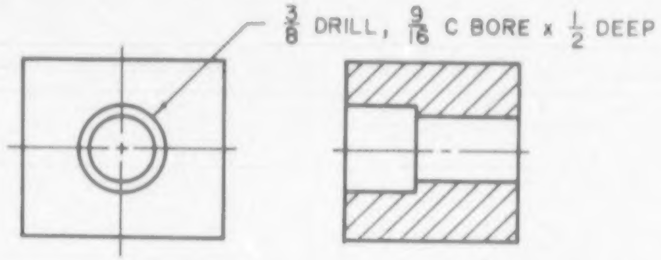
Example:


$\frac{5}{16}$ DRILL, $\frac{1}{2}$ DRILL x $\frac{7}{16}$ DEEP
DEPTH

INFORMATION SHEET

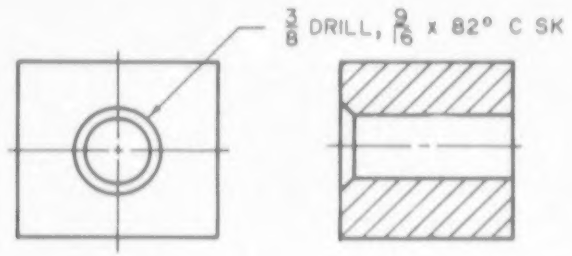
C. Counterbore–Diameter of the drill is given first, then the diameter of the bore by the depth it is to be cut

Example:


3/8 DRILL, 9/16 C BORE x 1/2 DEEP

D. Countersink–Diameter of the drill is given first, then the diameter of the top of countersink by the included angle of the countersink

Example:

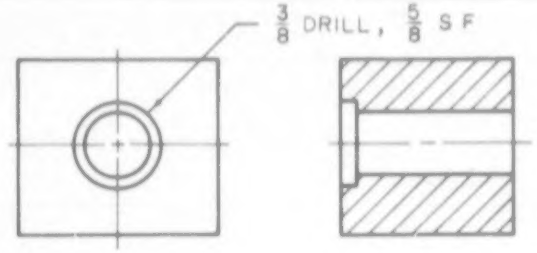

3/8 DRILL, 9/16 x 82° C SK

(NOTE: The standard countersink for manufacturing is 82°.)

E. Spot faced–Diameter of the drill is given first, then the diameter is given; the depth is not normally given for a spot face

(NOTE: Common practice is for a spot face to be cut 1/16" deep.)

Example:


3/8 DRILL, 5/8 S F

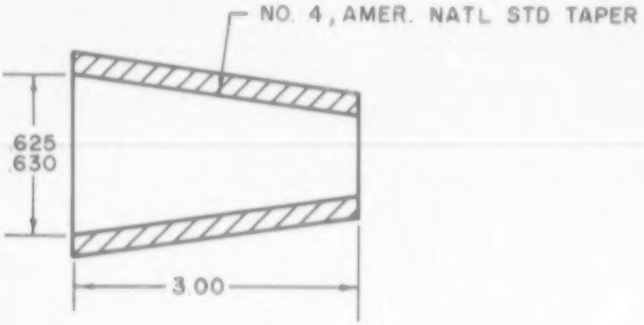
INFORMATION SHEET

F. Tapers

(NOTE: There are three methods of dimensioning a taper; the accuracy required and the machine process available to cut the taper will determine the method to use.)

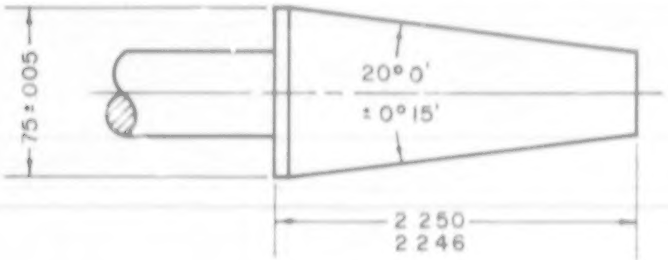
1. Standard machine tapers--The diameter, usually at the large end, and the length are applied to the view in the form of dimensions; the actual taper is given as a note such as "No. 4 AMER. NATL STD TAPER."

Example:



2. Non-critical tapers--The diameter at the large end, the length, and the included angle are applied to the view in the form of dimensions

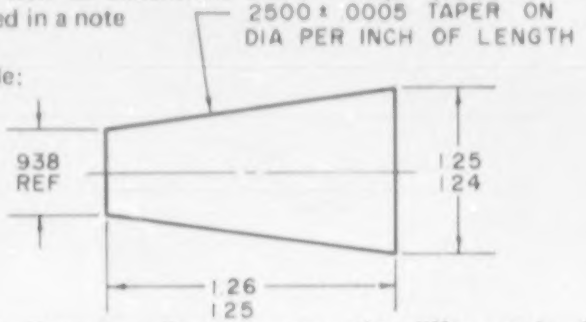
Example:



INFORMATION SHEET

3. Critical tapers--The diameter of the large end and the length are applied to the view as dimensions and the "taper per unit on diameter" is indicated in a note

   Example:


2500 ± 0005 TAPER ON
DIA PER INCH OF LENGTH
938
REF
1 25
1 24
1 26
1 25

   (NOTE: Taper on diameter means the difference in diameter per unit of length.)

G. Knurl

1. Diamond pattern

   a. Coarse knurl (33 pitch)

      (NOTE: Pitch is the distance betwen two points per inch.)

   b. Medium knurl (21 pitch)

   c. Fine knurl (14 pitch)

2. Straight pattern

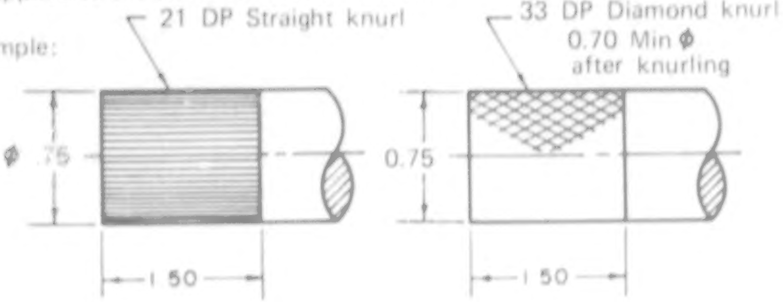
   a. Coarse knurl (33 pitch)

   b. Medium knurl (21 pitch)

   c. Fine knurl (14 pitch)

3. The pitch, type of knurl, and the minimum diameter after knurling are applied to the view in the form of a note

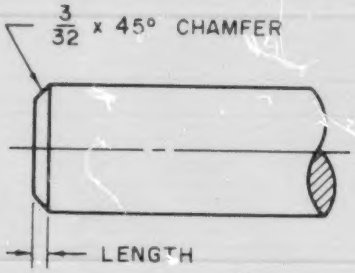
   Example:


21 DP Straight knurl
33 DP Diamond knurl
0.70 Min ϕ
after knurling
ϕ .75
0.75
1 50
1 50

INFORMATION SHEET

H. Chamfer--The length of the offset and the angle are applied to the view in the form of a note

Example:



I. Threads

1. Internal thread

   a. Through-drill--The following items are applied to the view in the form of a note

      1) Tap drill size

      2) Nominal thread diameter

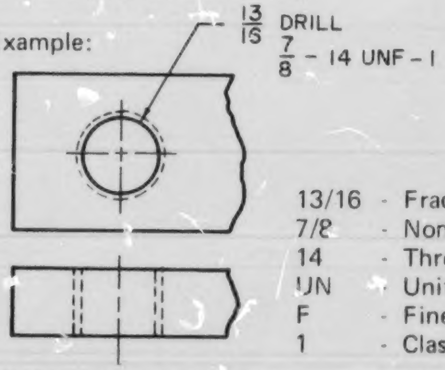
      3) Threads per inch

      4) Thread series type

      5) Class of thread fit

      6) LH (if it is left handed)

Example:



13/16	- Fractional size of tap drill
7/8	- Nominal thread diameter
14	- Threads per inch
UN	- Unified thread form
F	- Fine thread series
1	- Class 1 thread fit

(NOTE: Tap drill size is determined by referring to American National Standard Thread tables, *Machinery Handbook*, or various textbook appendixes.)

INFORMATION SHEET

b. Blind drill--The following items are applied to the view in the form of a note

1) Tap drill size

2) Depth of tap drill

3) Nominal thread diameter

4) Threads per inch

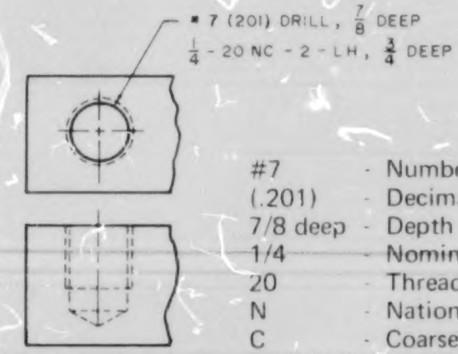
5) Thread series type

6) Class of thread fit

7) LH (if it is left handed)

8) Depth of thread

Example:



#7	-	Number size of tap drill
(.201)	-	Decimal size of tap drill
7/8 deep	-	Depth of tap drill
1/4	-	Nominal thread diameter
20	-	Threads per inch
N	-	National thread form
C	-	Coarse thread series
2	-	Class 2 thread fit
LH	-	Left hand threads
3/4 deep	-	Depth of thread

2. External thread--The following items are added to the view in the form of a note

a. Nominal thread diameter

b. Threads per inch

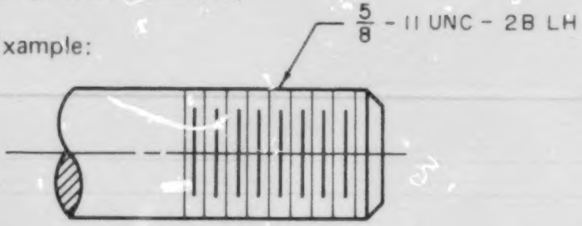
c. Thread series types

d. Class of thread fit

INFORMATION SHEET

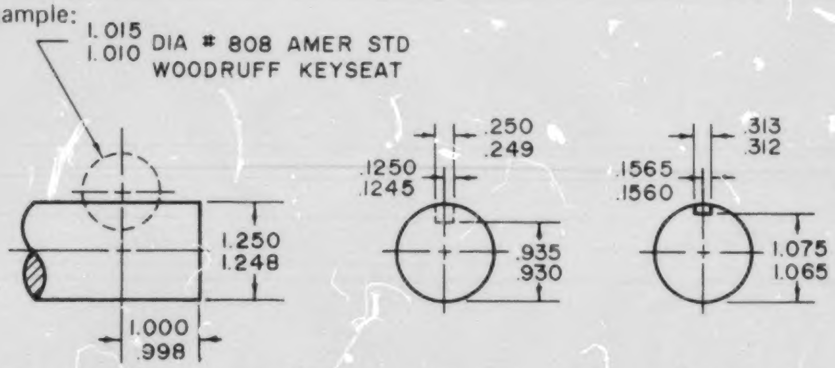
e. LH (if it is left handed)

Example:


$\frac{5}{8}$ - 11 UNC - 2B LH

J. Keyways--The size and number of the required key is given in the form of a note and the location on the shaft of the keyway is given in the form of dimensions on the two views showing the keyway

Example:

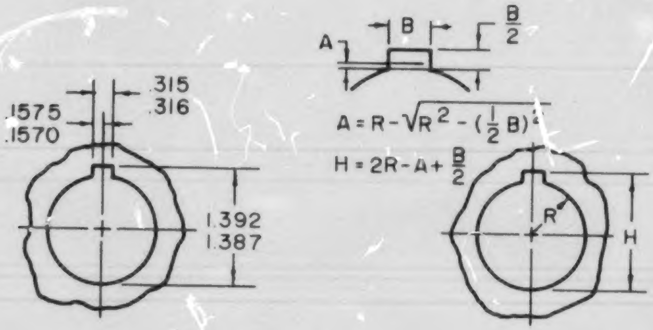

1.015
1.010 DIA # 808 AMER STD
WOODRUFF KEYSEAT
1.250
1.248
1.000
.998
.250
.249
.1250
.1245
.935
.930
.313
.312
.1565
.1560
1.075
1.065

(NOTE: Notice the use of a dimension to center the keyway in the shaft.)

K. Keyseats--The size and location of the slot is given in the form of dimensions applied to the view

(NOTE: The proper clearance for various keys can be obtained from a machinists' handbook.)

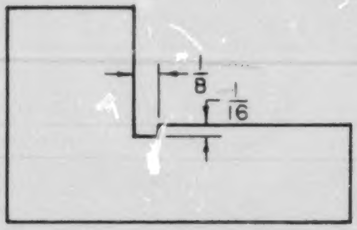
Example:


.315
.316
.1575
.1570
1.392
1.387
A
B
$\frac{B}{2}$
$A = R - \sqrt{R^2 - (\frac{1}{2}B)^2}$
$H = 2R - A + \frac{B}{2}$
R
H

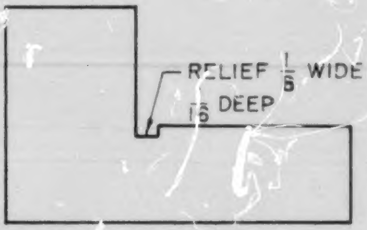
INFORMATION SHEET

L. Relief groove--The width and depth of a relief can be given by placing dimensions on the view or in the form of a note

Example:



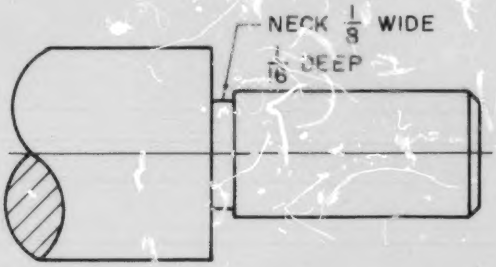
USING DIMENSIONS


RELIEF 1/8 WIDE
1/16 DEEP

USING A NOTE

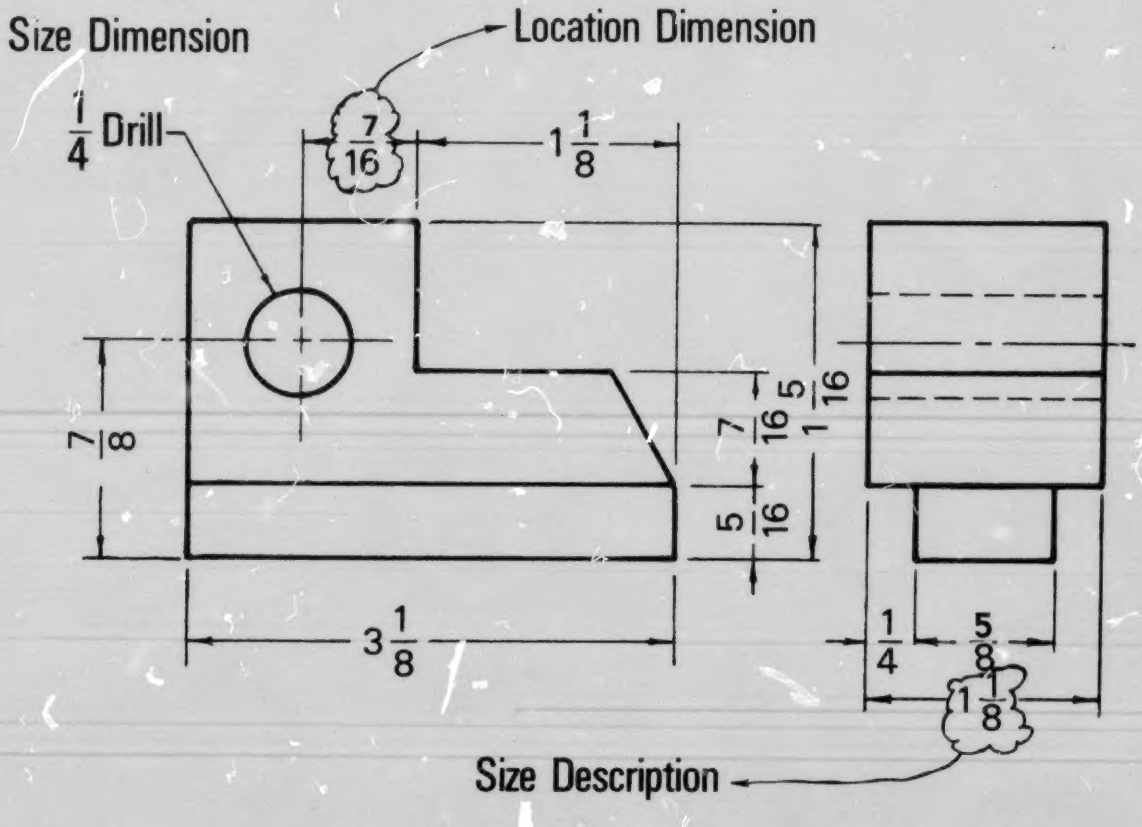
M. Neck--The width and depth of a neck is given in the form of a note

Example:

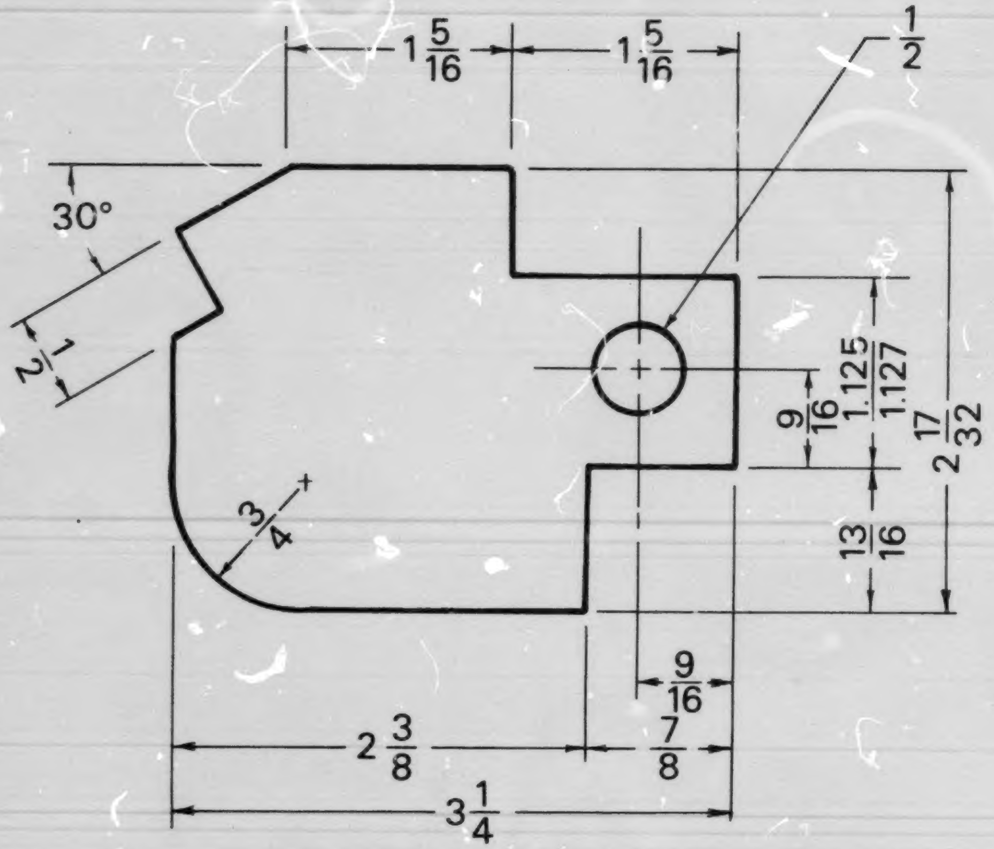

NECK 1/8 WIDE
1/16 DEEP

USING A NOTE

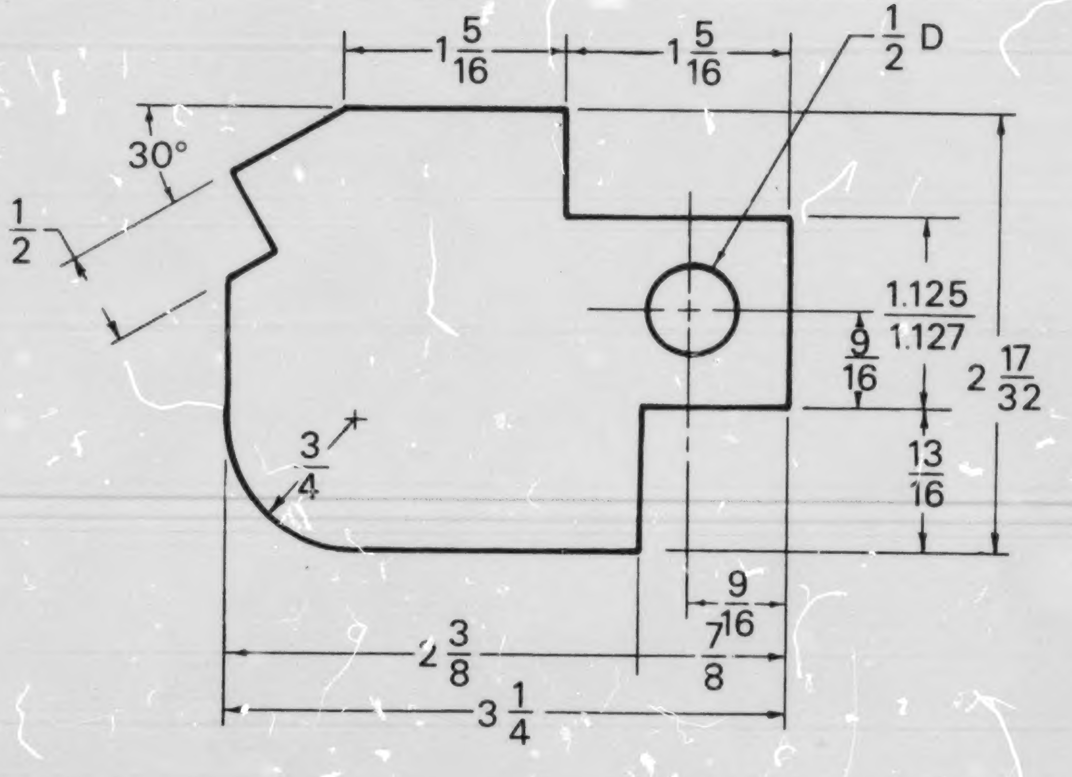
Descriptions and Dimensions


Size Dimension
Location Dimension
1/4 Drill
7/16
1 1/8
7/8
3 1/8
7/16
1 5/16
5/16
1/4
5/8
1 1/8
Size Description

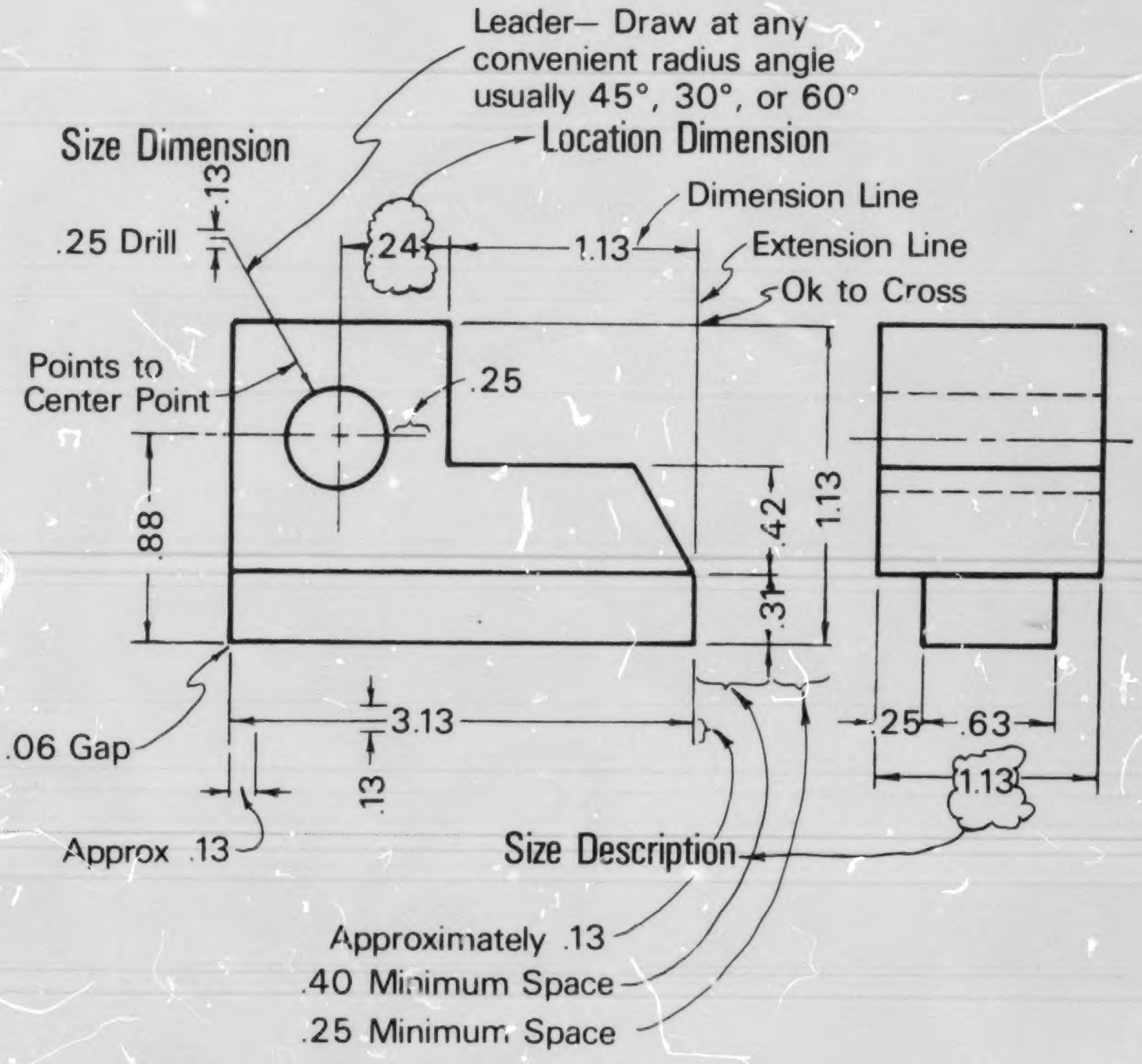
Aligned System


1 5/16
1 5/16
1/2
30°
1/2
1.125/1.127
9/16
2 17/32
13/16
3/4
9/16
2 3/8
7/8
3 1/4

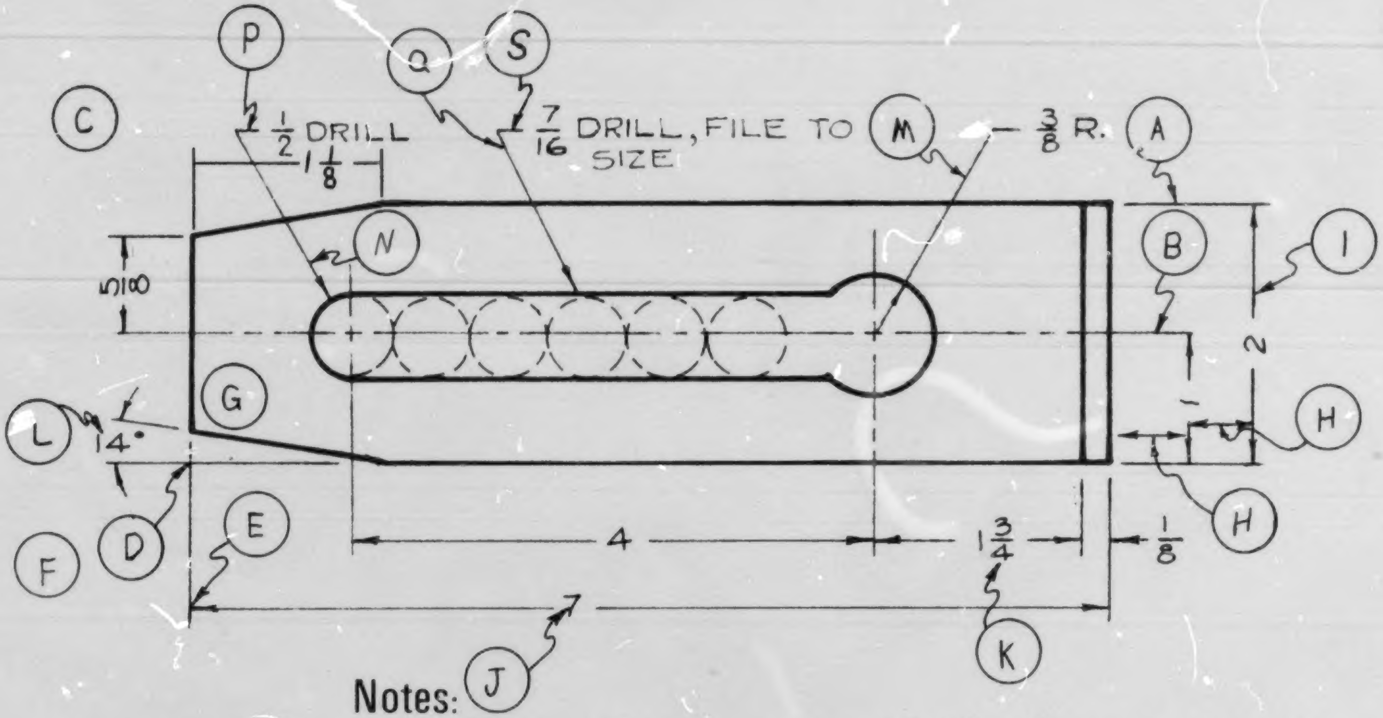
Unidirectional System


1 5/16
1 5/16
1/2 D
30°
1/2
1.125/1.127
9/16
2 17/32
3/4
13/16
9/16
2 3/8
7/8
3 1/4

Types of Lines


Leader— Draw at any convenient radius angle usually 45°, 30°, or 60°
Location Dimension
Size Dimension
.13
.25 Drill
.24
1.13
Dimension Line
Extension Line
Ok to Cross
Points to Center Point
.25
.88
.42
1.13
.31
.06 Gap
3.13
.13
Approx .13
.25
.63
1.13
Size Description
Approximately .13
.40 Minimum Space
.25 Minimum Space

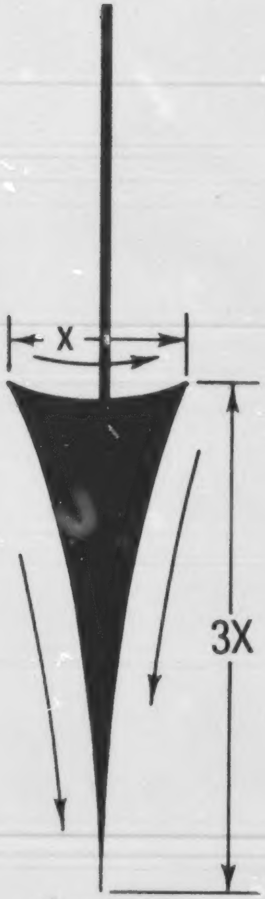
Rules for Lines


P
Q
S
C
1/2 DRILL
1 1/8
7/16 DRILL, FILE TO SIZE
M
3/8 R.
A
N
B
I
5/8
2
1
G
H
L
14°
D
E
F
H
4
1 3/4
1/8
J
K

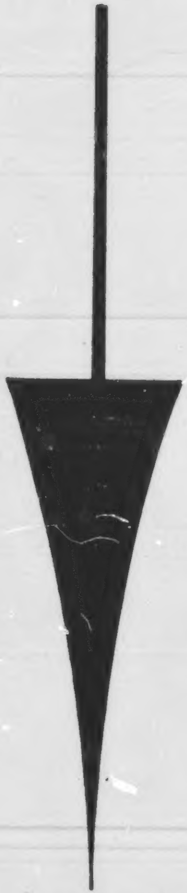
Notes:

1. Material to be made of 3/16 carbon steel.
2. Six pieces required.
3. Heat treat after machining.

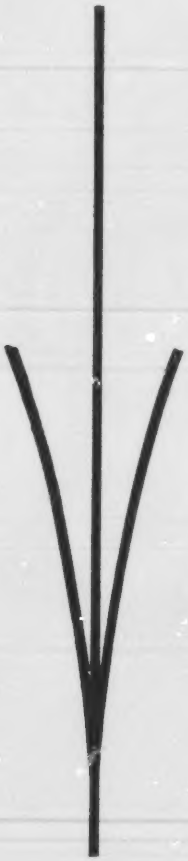
Arrowheads



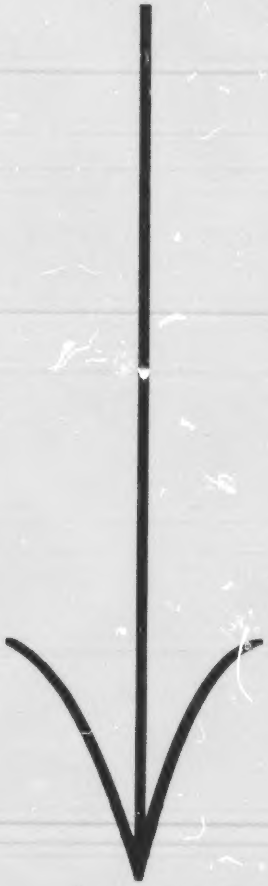
Correct



Incorrect

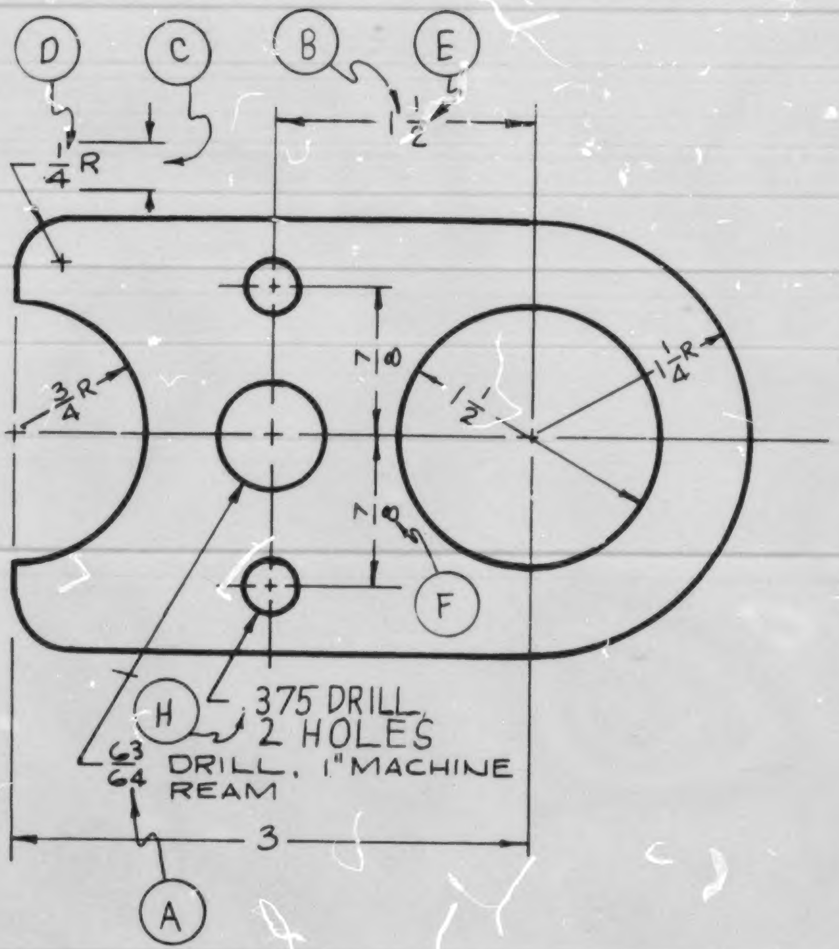


Correct
(In Some Fields)

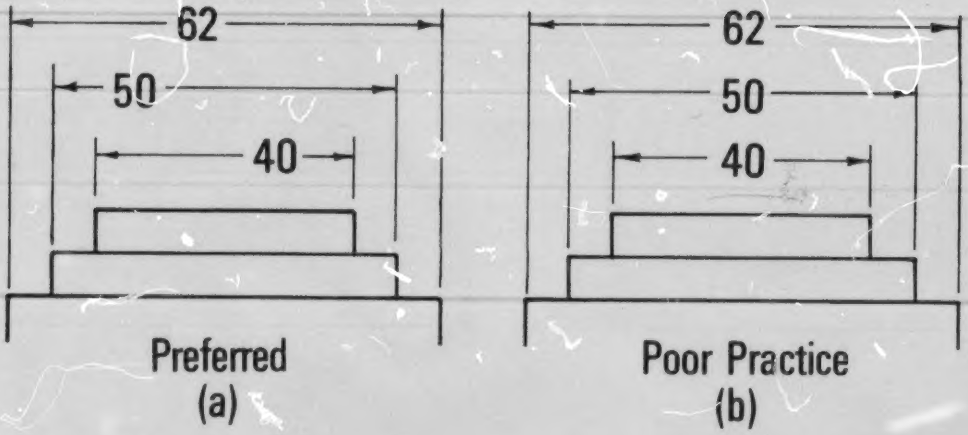


Incorrect

Rules For Figures


D
C
B
E
$\frac{1}{4}$R
$1\frac{1}{2}$
$\frac{3}{4}$R
$\frac{7}{8}$
$1\frac{1}{2}$
$1\frac{1}{4}$R
$\frac{7}{8}$
F
H
.375 DRILL,
2 HOLES
$\frac{63}{64}$ DRILL, 1" MACHINE REAM
3
A

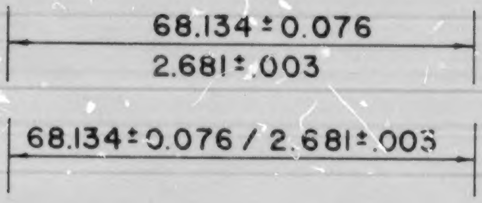
Staggered Numerals


62
50
40
62
50
40

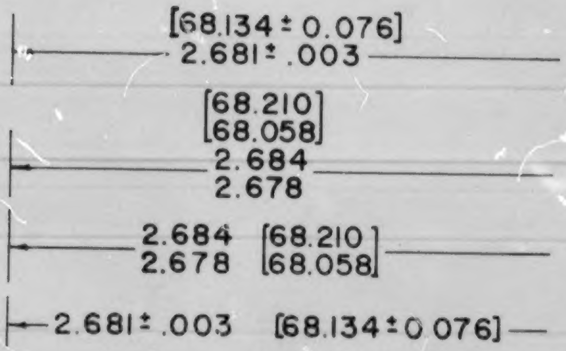
Preferred
(a)

Poor Practice
(b)

Dual Dimensioning Methods


68.134 ± 0.076
2.681 ± .003
68.134 ± 0.076 / 2.681 ± .003

Position Method


[68.134 ± 0.076]
2.681 ± .003
[68.210
68.058]
2.684
2.678
2.684 [68.210
2.678 68.058]
2.681 ± .003 [68.134 ± 0.076]

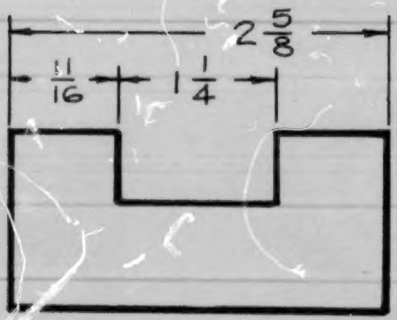
Bracket Method

CONVERSION CHART

mm	(inch)	mm	(inch)	mm	(inch)	mm	(inch)
0.025	.0010	6.6	.26	18.44	.726	43.7	1.72
0.038	.0015	7.1	.28	28.70	1.130	45.62	1.796
0.064	.0025	7.92	.312	28.83	1.135	45.77	1.802
0.076	.0030	8.13	.320	29.08	1.145	50.67	1.995
0.102	.0040	10.03	.395	29.21	1.150	50.80	2.000
0.127	.0050	10.29	.405	34.5	1.36	63.5	2.50
0.25	.010	10.7	.42	35.6	1.400	85.72	3.375
0.75	.030	10.9	.43	43.2	1.70	101.6	4.00
3.0	.12	18.29	.720				

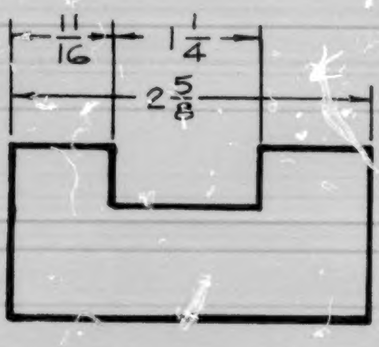
Chart Method

Placement of Dimensions



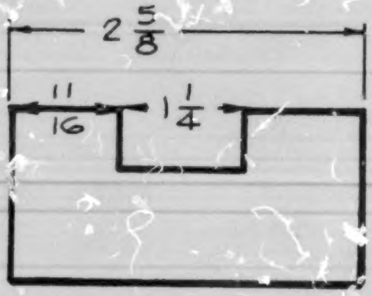
2 5/8
11/16
1 1/4

Correct



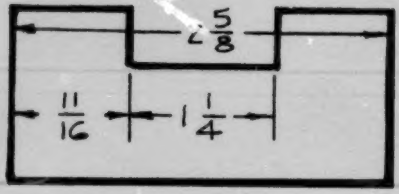
11/16
1 1/4
2 5/8

Incorrect



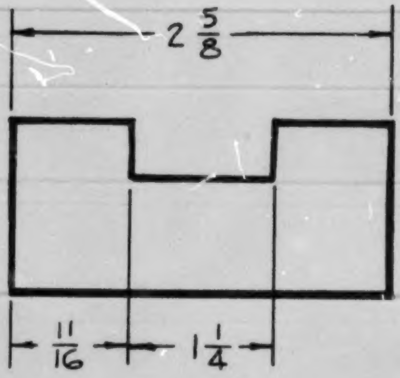
2 5/8
11/16
1 1/4

Incorrect



2 5/8
11/16
1 1/4

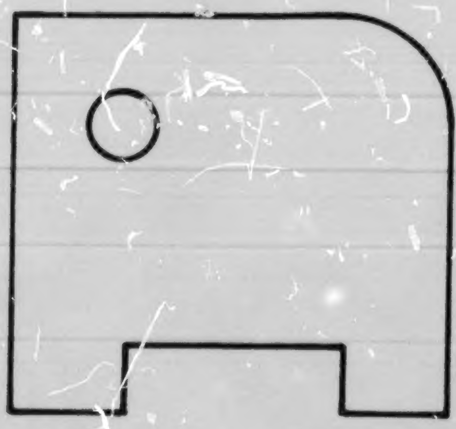
Incorrect



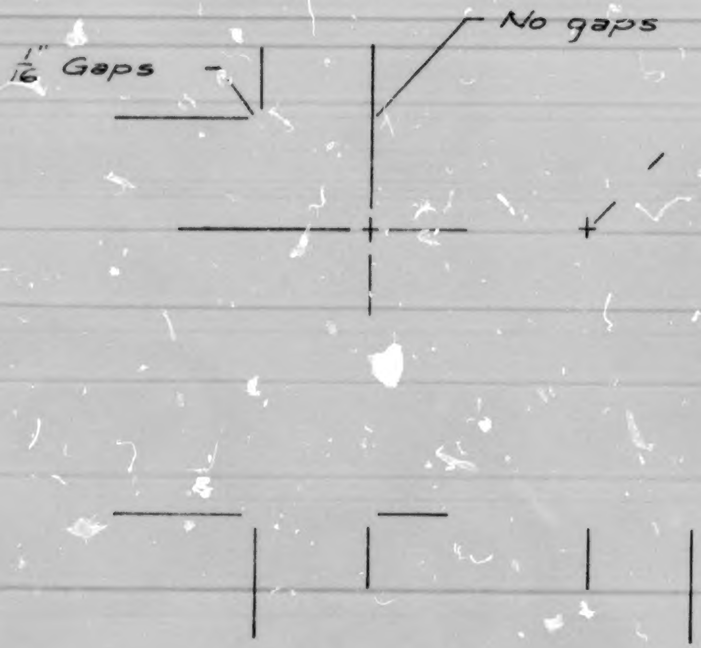
2 5/8
11/16
1 1/4

Incorrect

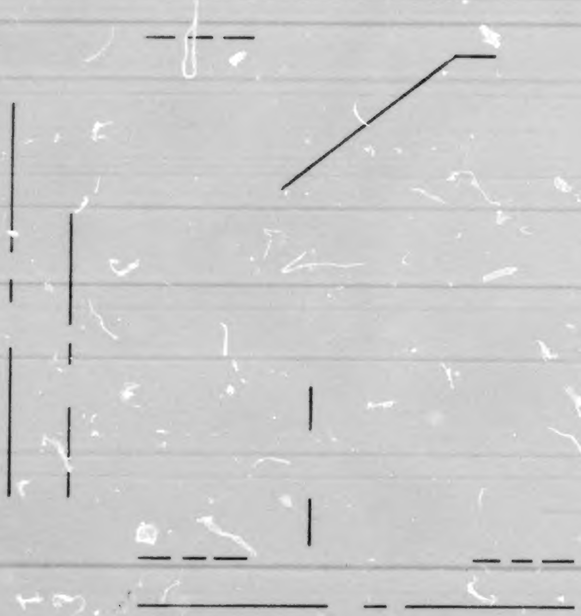
Steps in Applying Dimensions



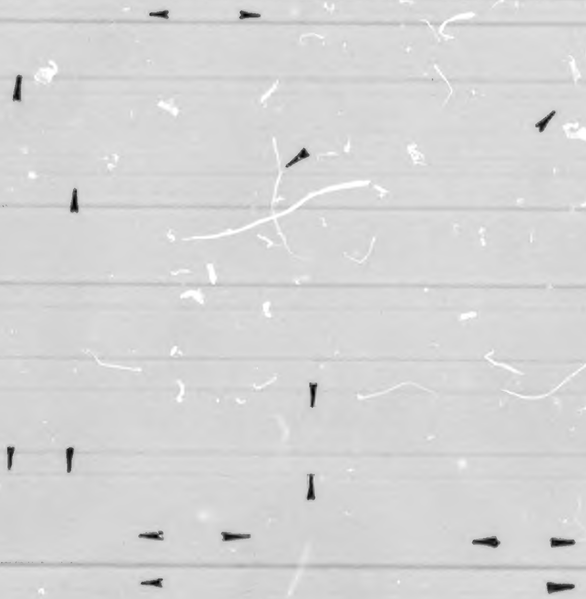
- Views of object completed


No gaps
1/16" Gaps

- Add extension and center lines



- Add dimension lines and leader lines



- Add arrowheads

Overlay 11C

$\frac{3}{8}$

$\frac{5}{16}$ DRILL

$\frac{1}{2}$

$\frac{1}{16}$

$\frac{1}{4}$

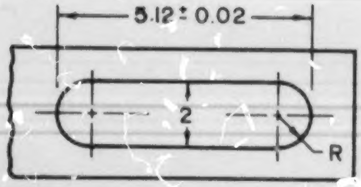
$\frac{7}{16}$

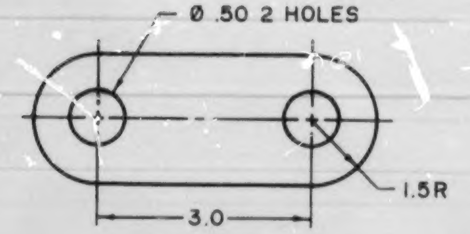
$\frac{7}{16}$

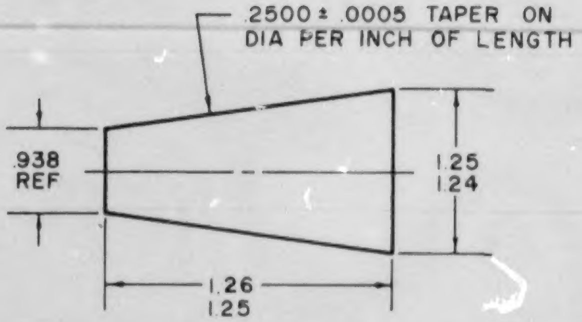
$1\frac{3}{4}$

Letter in dimensions

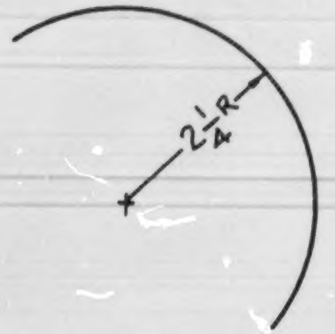
Rules Pertaining to Dimensioning Common Features



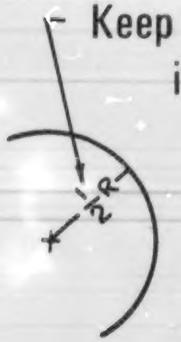

Ø .50 2 HOLES
1.5R
3.0


.2500 ± .0005 TAPER ON
DIA PER INCH OF LENGTH
.938
REF
1.25
1.24
1.26
1.25

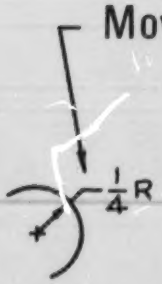
Dimensioning Arcs



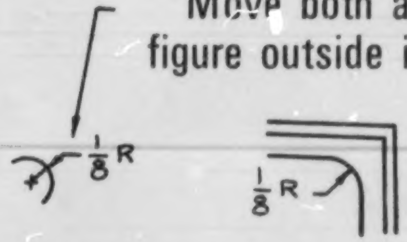
Keep figures inside if possible



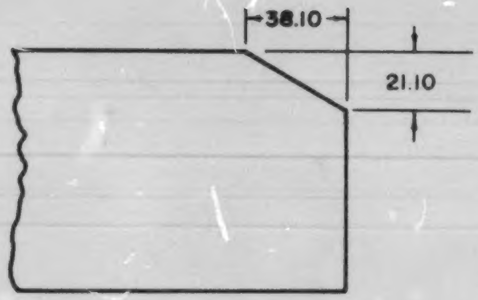
Move figure outside if necessary

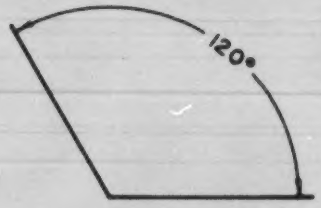


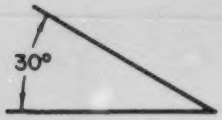
Move both arrow and figure outside if necessary

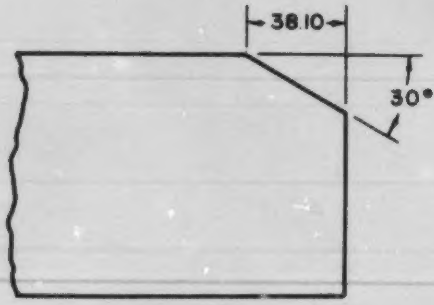


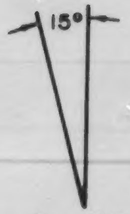
Dimensioning Angles

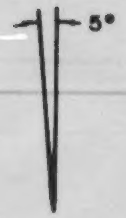








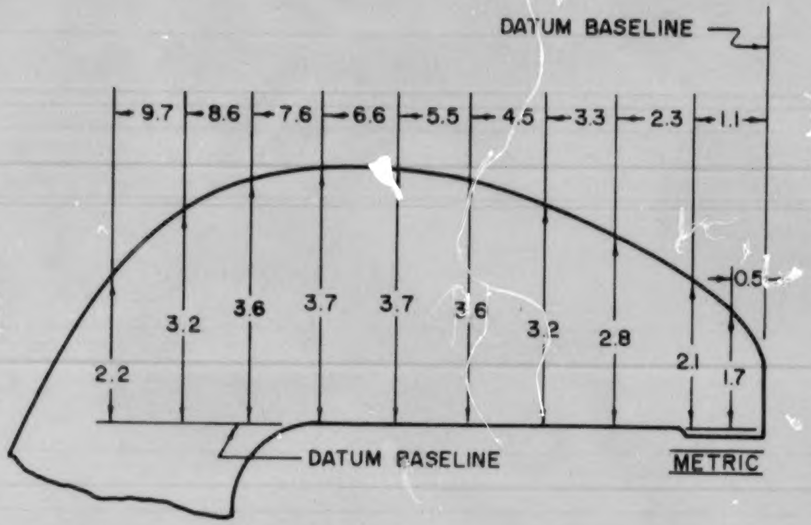


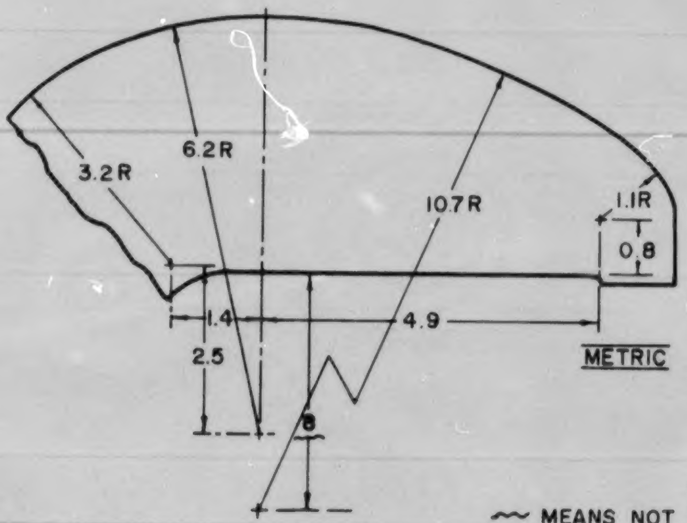


Angles May be Measures in

Degrees °
Minutes '
Seconds "

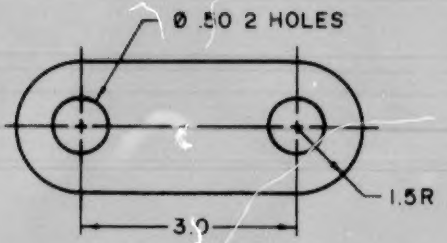
Dimensioning Curves

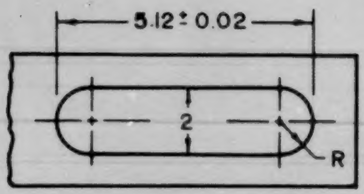

DATUM BASELINE
9.7
8.6
7.6
6.6
5.5
4.5
3.3
2.3
1.1
0.5
2.2
3.2
3.6
3.7
3.7
3.6
3.2
2.8
2.1
1.7
DATUM BASELINE
METRIC

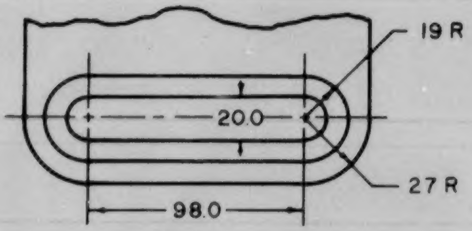

3.2R
6.2R
10.7R
1.1R
0.8
1.4
4.9
2.5
8
METRIC

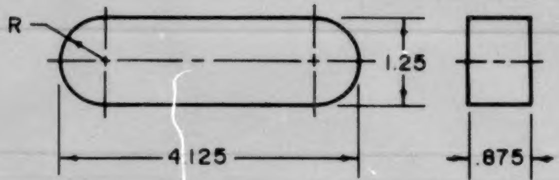
∼ MEANS NOT TO SCALE

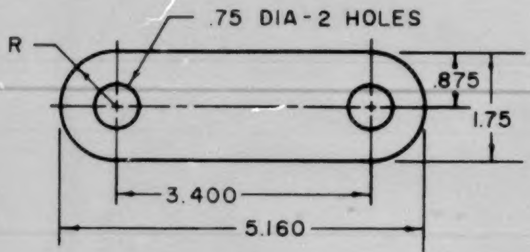
Dimemsioning Rounded End Shapes

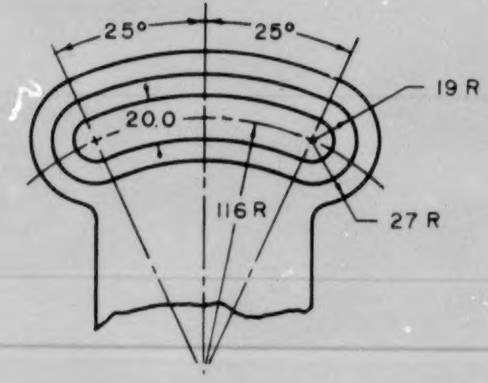

Ø .50 2 HOLES
1.5R
3.0

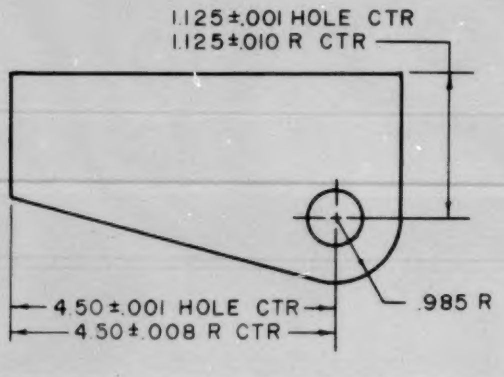



19 R
20.0
27 R
98.0

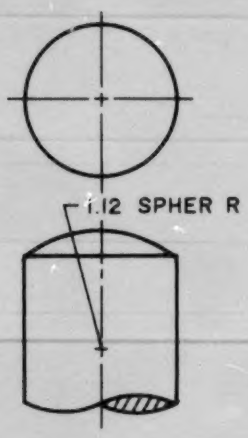

R
1.25
4.125
.875

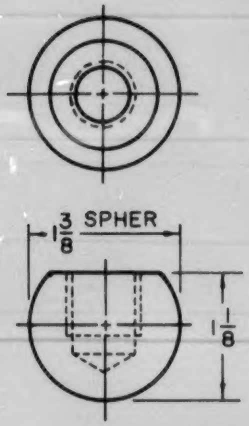

.75 DIA - 2 HOLES
R
.875
1.75
3.400
5.160


25°
25°
19 R
20.0
116 R
27 R

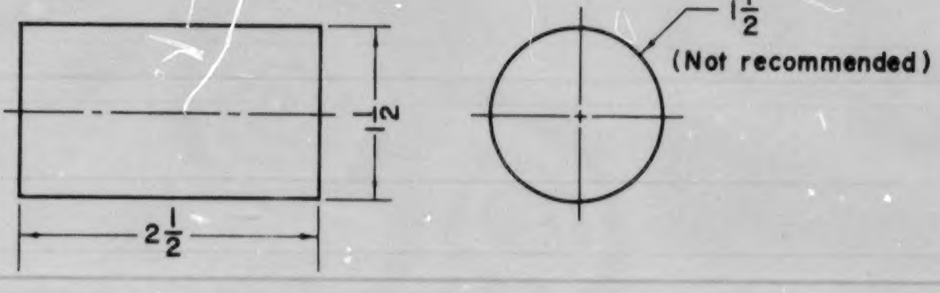

1.125 ±.001 HOLE CTR
1.125 ±.010 R CTR
.985 R
4.50 ±.001 HOLE CTR
4.50 ±.008 R CTR

Dimensioning Spherical Objects

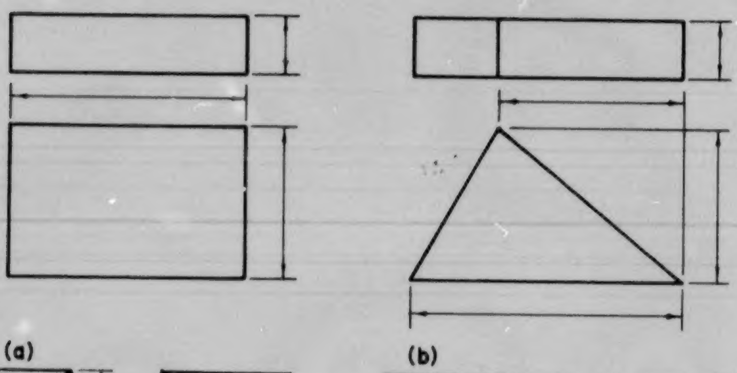


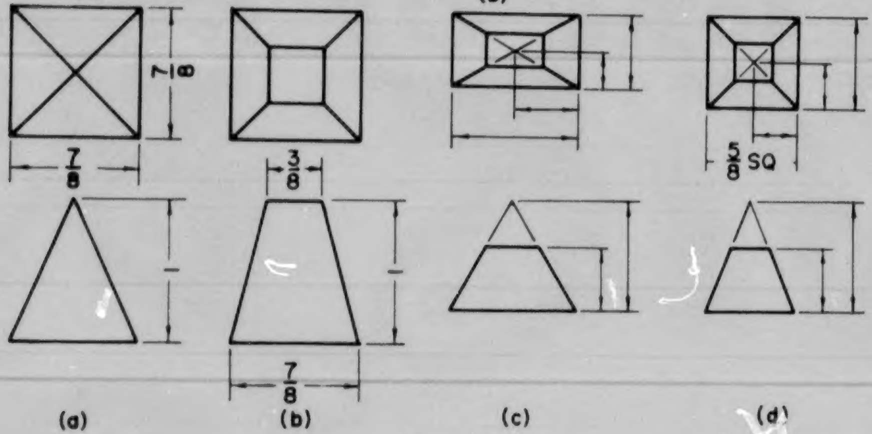

1 3/8 SPHER
1 1/8

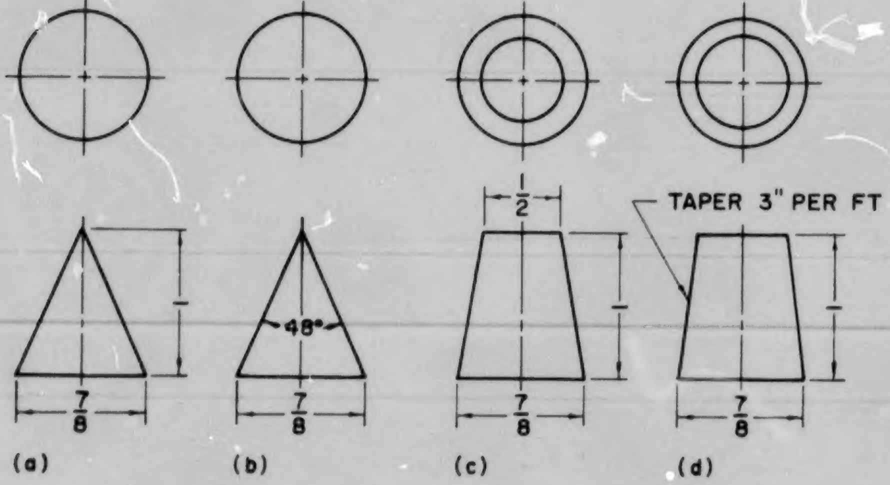
Dimensioning Cylindrical Objects


$1\frac{1}{2}$
(Not recommended)
$1\frac{1}{2}$
$2\frac{1}{2}$

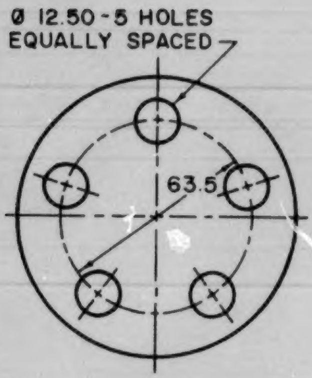
Dimensioning Cones, Pyramids & Prisms



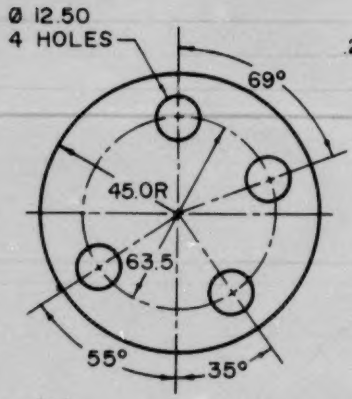

7/8
7/8
3/8
1
1
7/8
5/8 SQ
(a)
(b)
(c)
(d)


1/2
TAPER 3" PER FT
1
48°
1
1
7/8
7/8
7/8
7/8
(a)
(b)
(c)
(d)

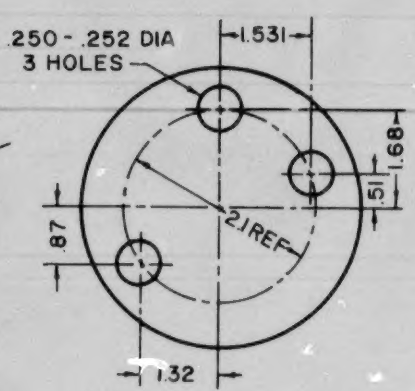
Dimension Features on a Circular Center Line


Ø 12.50 - 5 HOLES
EQUALLY SPACED
63.5

(a)


Ø 12.50
4 HOLES
69°
45.0R
63.5
55°
35°

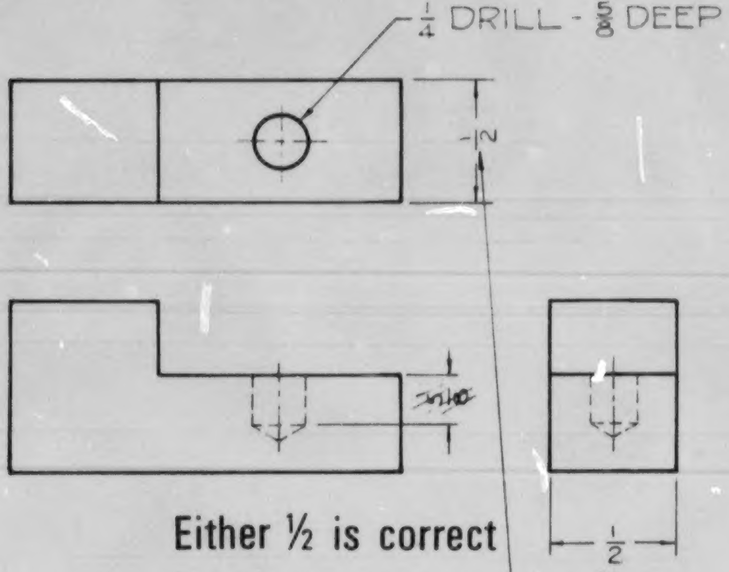
(b)


.250 - .252 DIA
3 HOLES
1.531
1.68
.51
.87
2.1 REF
1.32

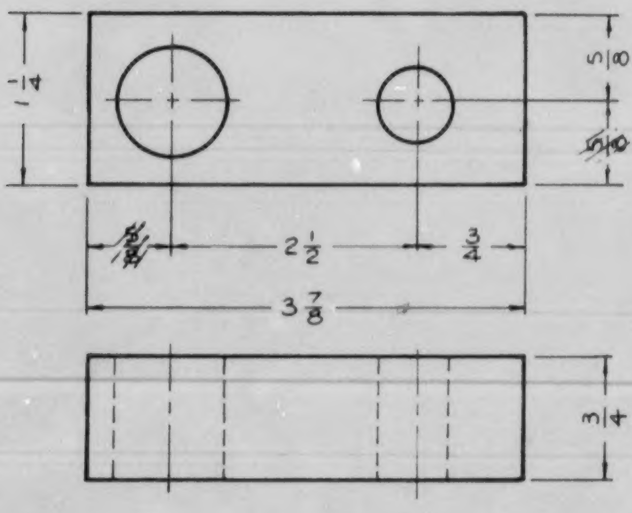
(c)

METRIC

Superfluous Dimensions

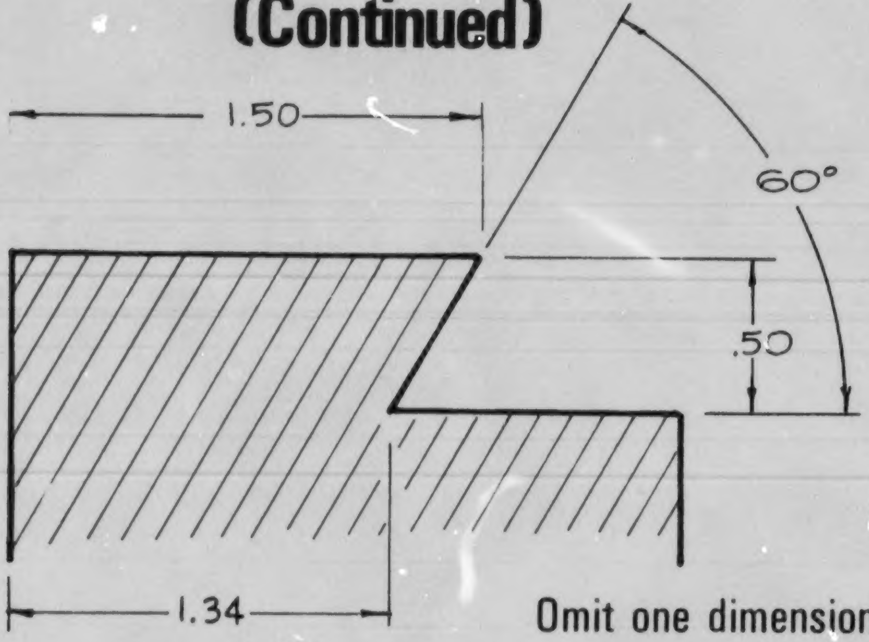

1/4 DRILL - 5/8 DEEP
1/2
5/8
1/2

Either ½ is correct
But Don't use Both
Give drill depth in note

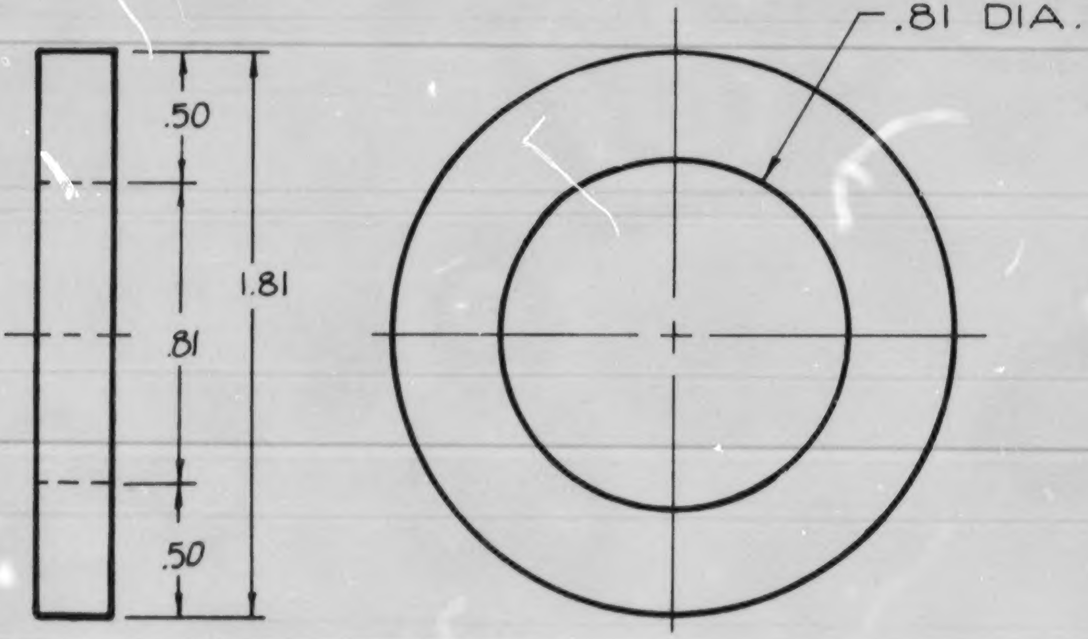

1 1/4
5/8
5/8
5/8
2 1/2
3/4
3 7/8
3/4

Omit one dimension in a chain

Superfluous Dimensions (Continued)

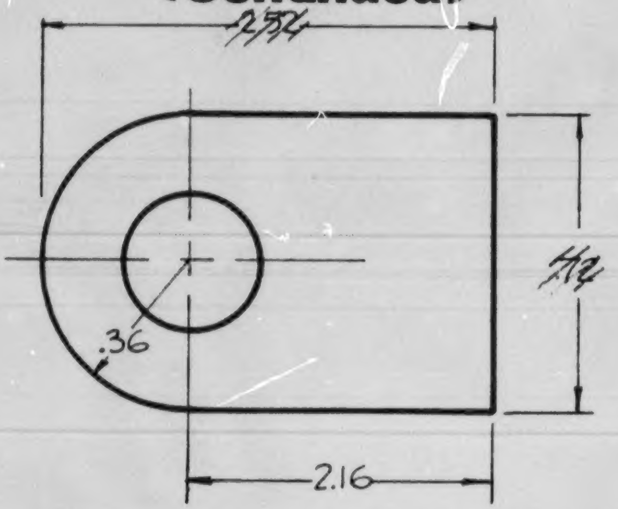

1.50
60°
.50
1.34

Omit one dimension of
the four shown

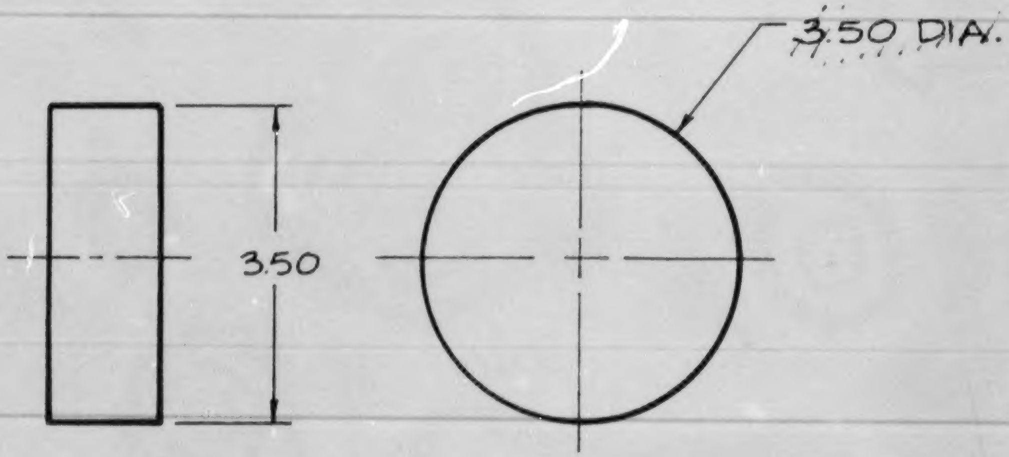

.50
.81
.50
1.81
.81 DIA.

Omit dimensions and use note for hole

Superfluous Dimensions (Continued)

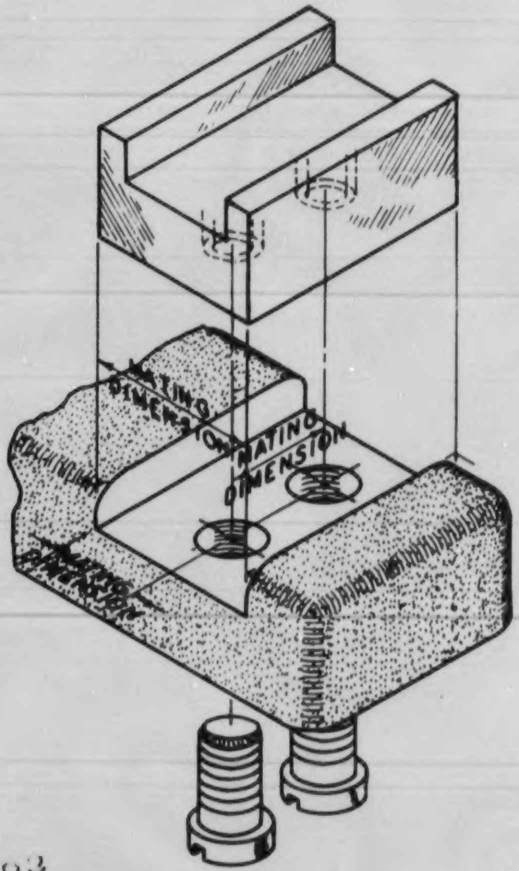


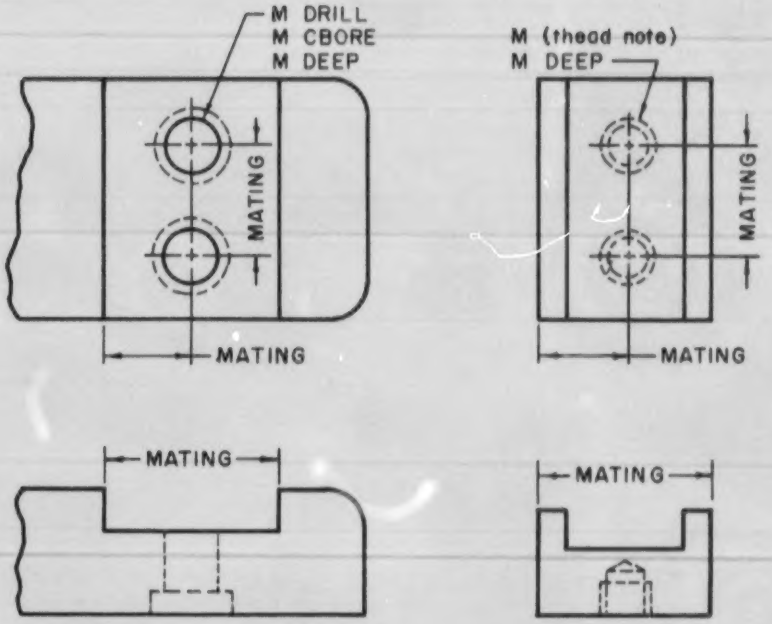
Omit width and overall length



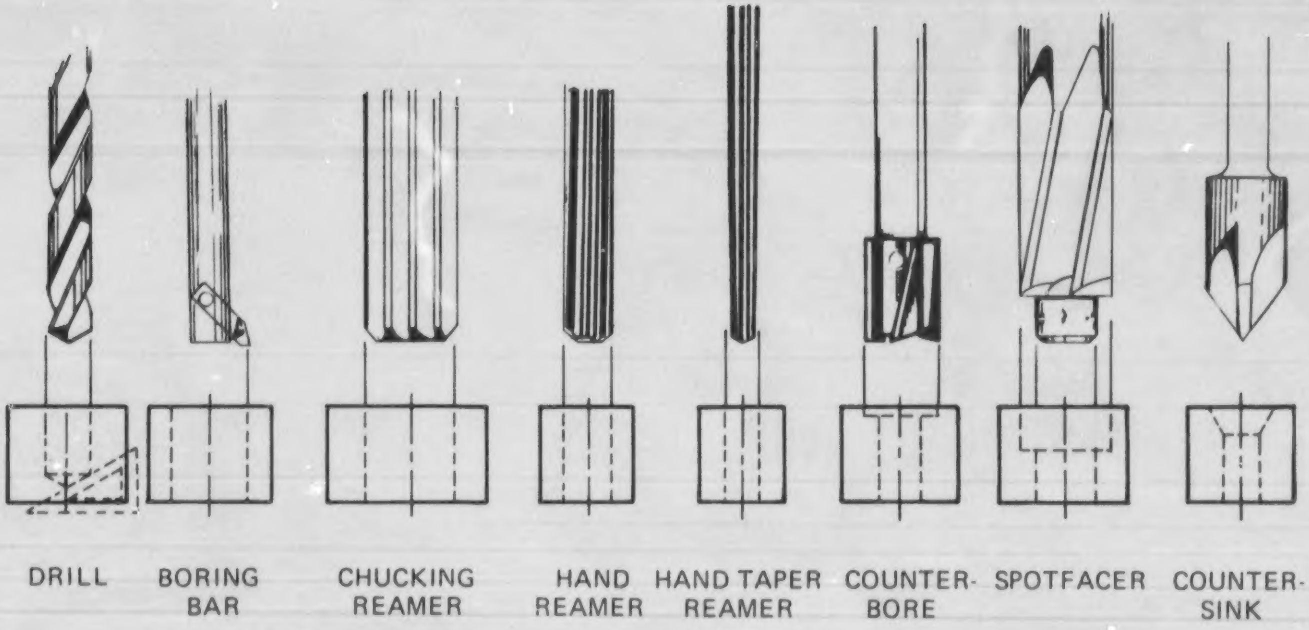
Omit diagonal diameter

Mating Dimensions


MATING DIMENSION
MATING DIMENSION
MATING DIMENSION


M DRILL
M CBORE
M DEEP
MATING
MATING
MATING
M (thead note)
M DEEP
MATING
MATING
MATING

Hole Operations


DRILL
BORING BAR
CHUCKING REAMER
HAND REAMER
HAND TAPER REAMER
COUNTER-BORE
SPOTFACER
COUNTER-SINK

TM 25

D II - 375

DIMENSIONING PROCEDURES
UNIT IV

HANDOUT #1--ABBREVIATIONS

A

Absolute	ABS
Accelerate	ACCEL
Accessory	ACCESS
Account	ACCT
Accumulate	ACCUM
Actual	ACT.
Adapter	ADPT
Addendum	ADD.
Addition	ADD.
Adjust	ADJ
Advance	ADV
After	AFT.
Aggregate	AGGR
Air Condition	AIR COND
Airplane	APL
Allowance	ALLOW
Alloy	ALY
Alteration	ALT
Alternate	ALT
Alternating Current	AC
Altitude	ALT
Aluminum	AL
American National Standard	AMER NATL STD
American Wire Gage	AWG
Amount	AMT
Ampere	AMP
Amplifier	AMPL
Anneal	ANL
Antenna	ANT.
Apartment	APT
Apparatus	APP
Appendix	APPX
Approved	APPD
Approximate	APPROX
Arc Weld	ARC W
Area	A
Armature	ARM.
Armor Plate	ARM PL
Army Navy	AN
Arrange	ARR.
Artificial	ART.
Asbestos	ASB
Asphalt	ASPH
Assemble	ASSEM
Assembly	ASSY
Assistant	ASST
Associate	ASSOC
Association	ASSN
Atomic	AT
Audible	AUD
Audio Frequency	AF
Authorized	AUTH
Automatic	AUTO
Auto-Transformer	AUTO TR
Auxiliary	AUX
Avenue	AVE
Average	AVG
Aviation	AVI
Azimuth	AZ

B

Babbitt	BAB
Back Feed	BF
Back Pressure	BP
Back to Back	B to B
Backface	BF
Balance	BAL
Ball Bearing	BB
Barometer	BAR
Base Line	BL
Base Plate	BP
Bearing	BRG
Bench Mark	BM
Bending Moment	M
Bent	BT
Bessemer	BESS
Between	BET.
Between Centers	BC
Between Perpendiculars	BP
Bevel	BEV
Bill of Material	B/M
Birmingham Wire Gage	BWG
Blank	BLK
Block	BLK
Blueprint	BP
Board	BD
Boiler	BLR
Boiler Feed	BF
Boiler Horsepower	BHP
Boiling Point	BP
Bolt Circle	BC
Both Faces	BF
Both Sides	BS
Both Ways	BW
Bottom	BOT
Bottom Chord	BC
Bottom Face	BF
Bracket	BRKT
Brake	BK
Brake Horsepower	BHP
Brass	BRS
Brazing	BRZG
Break	BRK
Brinell Hardness	BH
British Standard	BR STD
British Thermal Units	BTU
Broach	BRO
Bronze	BRZ
Brown & Sharpe (Wire Gage, same as AWG)	B&S
Building	BLDG
Bulkhead	BHD
Burnish	BNH
Bushing	BUSH
Button	BUT

C

Cabinet	CAB.
Calculate	CALC
Calibrate	CAL
Cap Screw	CAP SCR
Capacity	CAP
Carburetor	CARB
Carburize	CARB
Carriage	CRG
Case Harden	CH
Cast Iron	CI
Cast Steel	CS
Casting	CSTG
Castle Nut	CAS NUT
Catalogue	CAT
Cement	CEM
Center	CTR
Center Line	CL
Center of Gravity	CG
Center of Pressure	CP
Center to Center	C to C
Centering	CTR
Chamfer	CHAM
Change	CHG
Channel	CHAN
Check	CHK
Check Valve	CV
Chord	CHD
Circle	CIR
Circular	CIR
Circular Pitch	CP
Circumference	CIRC
Clear	CLR
Clearance	CL
Clockwise	CW
Coated	CTD
Cold Drawn	CD
Cold Drawn Steel	CDS
Cold Finish	CF
Cold Punched	CP
Cold Rolled	CR
Cold Rolled Steel	CRS
Combination	COMB.
Combustion	COMB
Commercial	COML
Company	CO
Complete	COMPL
Compress	COMP
Concentric	CONC
Concrete	CONC
Condition	COND
Connect	CONN
Constant	CONST
Construction	CONST
Contact	CONT
Continue	CONT
Copper	COP.
Corner	COR
Corporation	CORP
Correct	CORR
Corrugate	CORR
Cotter	COT
Counter	CTR
Counter Clockwise	CCW
Counterbore	CBORE
Counterdrill	CDRILL
Counterpunch	CPUNCH
Countersink	CSK
Coupling	CPLG
Cover	COV
Cross Section	XSECT
Cubic	CU
Cubic Foot	CU FT
Cubic Inch	CU IN.
Current	CUR
Customer	CUST
Cyanide	CYN

D

Decimal	DEC
Dedendum	DED
Deflect	DEFL
Degree	(°) DEG
Density	D
Department	DEPT
Design	DSGN
Detail	DET
Develop	DEV
Diagonal	DIAG
Diagram	DIAG
Diameter	DIA
Diametral Pitch	DP
Dimension	DIM.
Discharge	DISCH
Distance	DIST
Division	DIV
Double	DBL
Dovetail	DVTL
Dowel	DWL
Down	DN
Dozen	DOZ
Drafting	DFTG
Draftsman	DFTSMN
Drawing	DWG
Drill or Drill Rod	DR
Drive	DR
Drive Fit	DF
Drop	D
Drop Forge	DF
Duplicate	DUP

E

Each	EA
East	E
Eccentric	ECC
Effective	EFF
Elbow	ELL
Electric	ELEC
Elementary	ELEM
Elevate	ELEV
Elevation	EL
Engine	ENG
Engineer	ENGR
Engineering	ENGRG
Entrance	ENT
Equal	EQ
Equation	EQ
Equipment	EQUIP
Equivalent	EQUIV
Estimate	EST
Exchange	EXCH
Exhaust	EXH
Existing	EXIST.
Exterior	EXT
Extra Heavy	X HVY
Extra Strong	X STR
Extrude	EXTR

F

Fabricate	FAB
Face to Face	F to F
Fahrenheit	F
Far Side	FS
Federal	FED.
Feed	FD
Feet	(') FT
Figure	FIG.
Fillet	FIL
Fillister	FIL
Finish	FIN.
Finish All Over	FAO
Flange	FLG
Flat	F
Flat Head	FH
Floor	FL
Fluid	FL
Focus	FOC
Foot	(') FT
Force	F
Forged Steel	FST
Forging	FORG
Forward	FWD
Foundry	FDRY
Frequency	FREQ
Front	FR
Furnish	FURN

HANDOUT #1

G	
Gage or Gauge	GA
Gallon	GAL
Galvanize	GALV
Galvanized Iron	GI
Galvanized Steel	GS
Gasket	GSKT
General	GEN
Glass	GL
Government	GOVT
Governor	GOV
Grade	GR
Graduation	GRAD
Graphite	GPH
Grind	GRD
Groove	GRV
Ground	GRD
H	
Half-Round	½RD
Handle	HDL
Hanger	HGR
Hard	H
Harden	HDN
Hardware	HDW
Head	HD
Headless	HDLS
Heat	HT
Heat Treat	HT TR
Heavy	HVY
Hexagon	HEX
High-Pressure	HP
High-Speed	HS
Horizontal	HOR
Horsepower	HP
Hot Rolled	HR
Hot Rolled Steel	HRS
Hour	HR
Housing	HSG
Hydraulic	HYD
I	
Illustrate	ILLUS
Inboard	INBD
Inch	(") IN.
Inches per Second	IPS
Inclosure	INCL
Include	INCL
Inside Diameter	ID
Instrument	INST
Interior	INT
Internal	INT
Intersect	INT
Iron	I
Irregular	IRREG
J	
Joint	JT
Joint Army Navy	JAN
Journal	JNL
Junction	JCT
K	
Key	K
Keyseat	KST
Keyway	KWY
L	
Laboratory	LAB
Laminate	LAM
Lateral	LAT
Left	L
Left-Hand	LH
Length	LG
Length Over All	LOA
Letter	LTR
Light	LT
Line	L
Locate	LOC
Logarithm	LOG.
Long	LG
Lubricate	LUB
Lumber	LBR
M	
Machine	MACH
Machine Steel	MS
Maintenance	MAINT
Malleable	MALL
Malleable Iron	MI
Manual	MAN.
Manufacture	MFR
Manufactured	MFD
Manufacturing	MFG
Material	MATL
Maximum	MAX
Mechanical	MECH
Mechanism	MECH
Median	MED
Metal	MET.
Meter	M
Miles	MI
Miles per Hour	MPH
Millimeter	MM
Minimum	MIN
Minute	(') MIN
Miscellaneous	MISC
Month	MO
Morse Taper	MOR T
Motor	MOT
Mounted	MTD
Mounting	MTG
Multiple	MULT
Music Wire Gage	MWG
N	
National	NATL
Natural	NAT
Near Face	NF
Near Side	NS
Negative	NEG
Neutral	NEUT
Nominal	NOM
Normal	NOR
North	N
Not to Scale	NTS
Number	NO.
O	
Obsolete	OBS
Octagon	OCT
Office	OFF.
On Center	OC
Opposite	OPP
Optical	OPT
Original	ORIG
Outlet	OUT
Outside Diameter	OD
Outside Face	OF
Outside Radius	OR
Overall	OA
P	
Pack	PK
Packing	PKG
Page	P
Paragraph	PAR.
Part	PT
Patent	PAT
Pattern	PATT
Permanent	PERM
Perpendicular	PERP
Piece	PC
Piece Mark	PC MK
Pint	PT
Pitch	P
Pitch Circle	PC
Pitch Diameter	PD
Plastic	PLSTC
Plate	PL
Plumbing	PLMB
Point	PT
Point of Curve	PC
Point of Intersection	PI
Point of Tangent	PT
Polish	POL
Position	POS
Potential	POT.
Pound	LB
Pounds per Square Inch	PSI
Power	PWR
Prefabricated	PREFAB
Preferred	PFD
Prepare	PREP
Pressure	PRESS.
Process	PROC
Production	PROD
Profile	PF
Propeller	PROP
Publication	PUB
Push Button	PB
Q	
Quadrant	QUAD
Quality	QUAL
Quarter	QTR
R	
Radial	RAD
Radius	R
Railroad	RR
Ream	RM
Received	RECD
Record	REC
Rectangle	RECT
Reduce	RED.
Reference Line	REF L
Reinforce	REINF
Release	REL
Relief	REL
Remove	REM
Require	REQ
Required	REQD
Return	RET
Reverse	REV
Revolution	REV
Revolutions per Minute	RPM
Right	R
Right Hand	RH
Rivet	RIV
Rockwell Hardness	RH
Roller Bearing	RB
Room	RM
Root Diameter	RD
Root Mean Square	RMS
Rough	RGH
Round	RD
S	
Schedule	SCH
Schematic	SCHEM
Scleroscope Hardness	SH
Screw	SCR
Second	SEC
Section	SECT
Semi-Steel	SS
Separate	SEP
Set Screw	SS
Shaft	SFT
Sheet	SH
Shoulder	SHLD
Side	S
Single	S
Sketch	SK
Sleeve	SLV
Slide	SL
Slotted	SLOT.
Small	SM
Socket	SOC
Space	SP
Special	SPL
Specific	SP
Spot Faced	SF
Spring	SPG
Square	SQ
Standard	STD
Station	STA
Stationary	STA
Steel	STL
Stock	STK
Straight	STR
Street	ST
Structural	STR
Substitute	SUB
Summary	SUM.
Support	SUP.
Surface	SUR
Symbol	SYM
System	SYS
T	
Tangent	TAN.
Taper	TPR
Technical	TECH
Template	TEMP
Tension	TENS.
Terminal	TERM.
Thick	THK
Thousand	M
Thread	THD
Threads per Inch	TPI
Through	THRU
Time	T
Tolerance	TOL
Tongue & Groove	T & G
Tool Steel	TS
Tooth	T
Total	TOT
Transfer	TRANS
Typical	TYP
U	
Ultimate	ULT
Unit	U
Universal	UNIV
V	
Vacuum	VAC
Valve	V
Variable	VAR
Versus	VS
Vertical	VERT
Volt	V
Volume	VOL
W	
Wall	W
Washer	WASH.
Watt	W
Week	WK
Weight	WT
West	W
Width	W
Wood	WD
Woodruff	WDF
Working Point	WP
Working Pressure	WP
Wrought	WRT
Wrought Iron	WI
X, Y, Z	
Yard	YD
Year	YR

DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #1--WRITE PROPER DIMENSION NOTES FOR STANDARD MACHINE MANUFACTURED FEATURES

Premise: Proper dimension notes for standard machine manufactured features can be written by using the procedure in the following example.

Example:

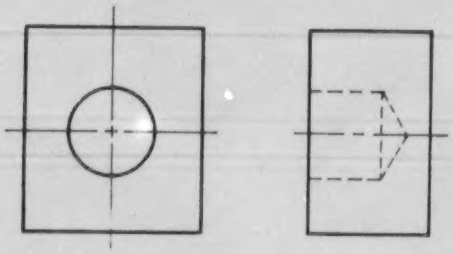
1. Determine what information goes into the note

   (NOTE: This may require using reference tables for features such as tap drill sizes or key sizes.)

2. Determine in what order machining operations will be performed
3. Add leader lines to views
4. Add guidelines for lettering
5. Letter note

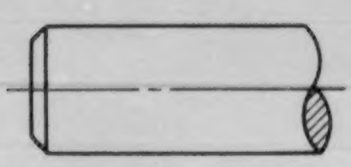
Directions: Dimension the following standard features correctly by adding all necessary notes and dimensions to the views. Dimensions can be taken directly from the views.

Problem A: Blind drill

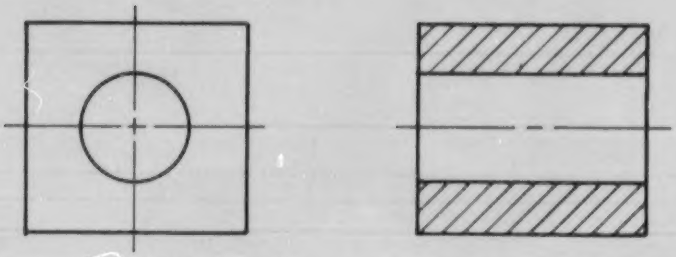


ASSIGNMENT SHEET #1

Problem B: Chamfer

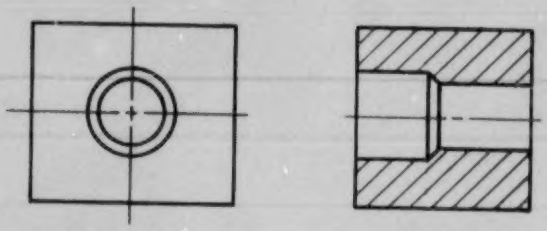


Problem C: Ream

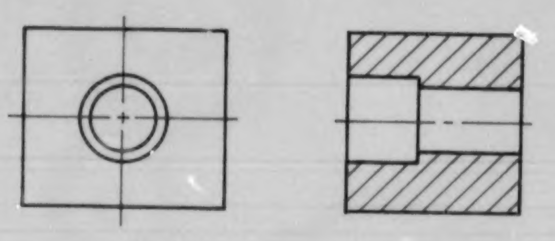


ASSIGNMENT SHEET #1

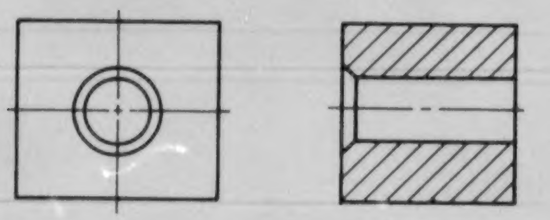
Problem D: Counterdrill



Problem E: Counterbore

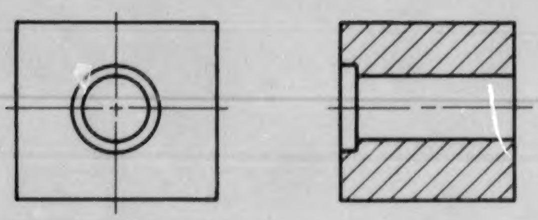


Problem F: Countersink

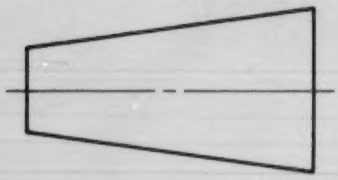


ASSIGNMENT SHEET #1

Problem G: Spot faced

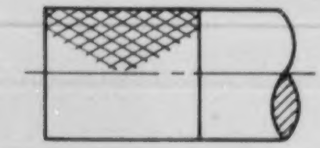


Problem H: Non-critical taper

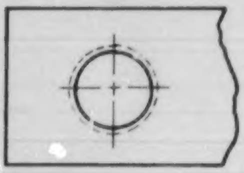


ASSIGNMENT SHEET #1

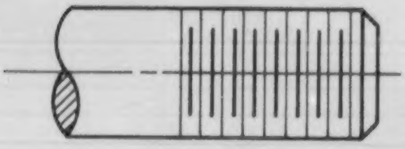
Problem I: Knurl



Problem J: Thread



UNF



UNC

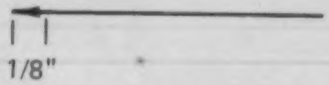
DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #2--CONSTRUCT ARROWHEADS

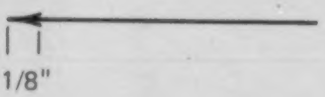
Premise: Arrowheads add much to a drawing if constructed correctly. They must be uniform in size and shape and the drafter must be able to construct them with speed, neatness, and accuracy. Arrowheads can be constructed correctly by using either form in the following example.

Example:

1. Conventional

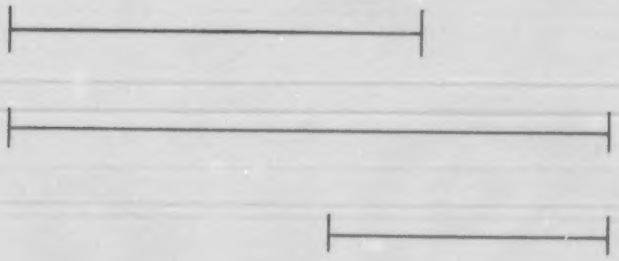


2. USA Standard



Directions: Place arrowheads at all intersecting lines below.

Problem:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #3--DIMENSION ARCS

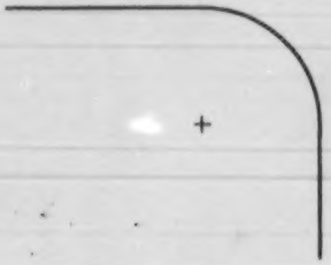
Premise: Arcs can be dimensioned by using the procedure in the following example.

Example:

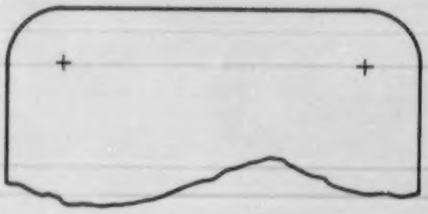
1. Determine if there is room inside the arc for either the numeral or the arc or both
2. Determine best location for leader line
3. Draw in leader line and add arrowhead
4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

Directions: Dimension the following arcs and radii using correct dimensioning procedures.

Problem A:

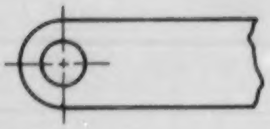


Problem B:

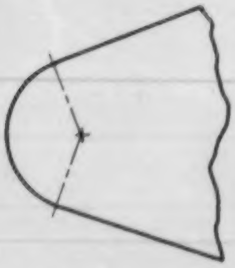


ASSIGNMENT SHEET #3

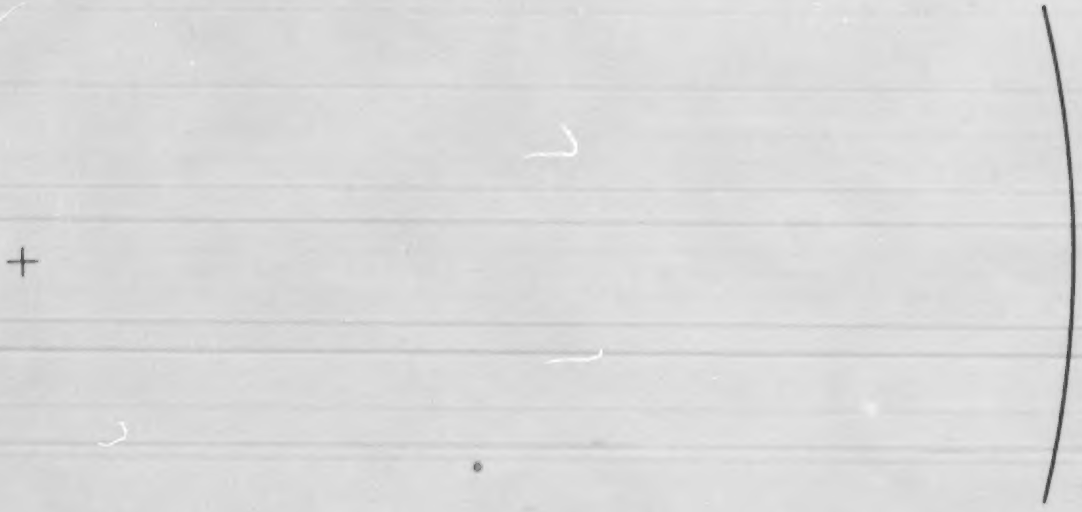
Problem C:



Problem D:

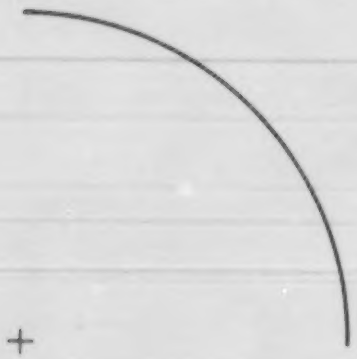


Problem E: 20" Radius

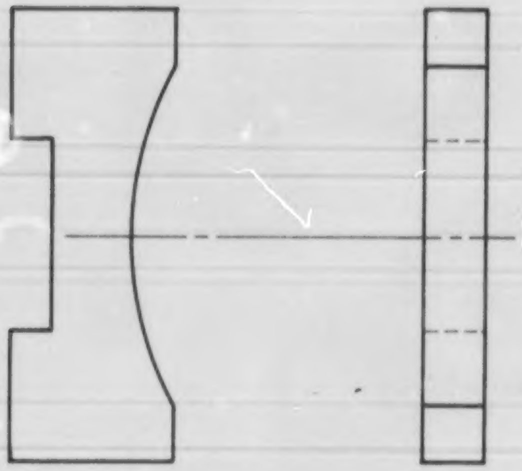


ASSIGNMENT SHEET #3

Problem F:

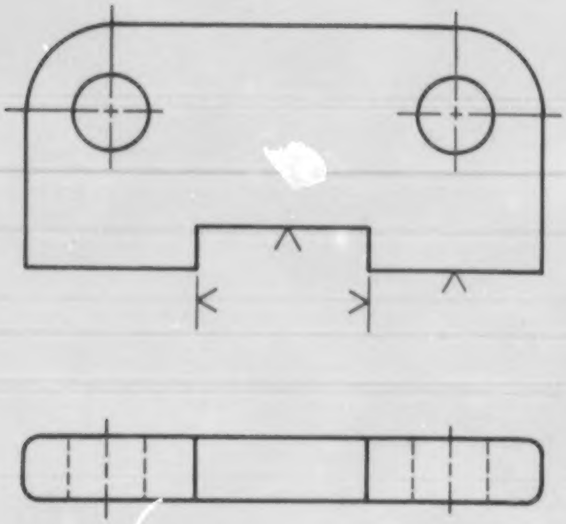


Problem G:



ASSIGNMENT SHEET #3

Problem H:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #4--DIMENSION ANGLES

Premise: Angles can be dimensioned by using the procedure in the following example.

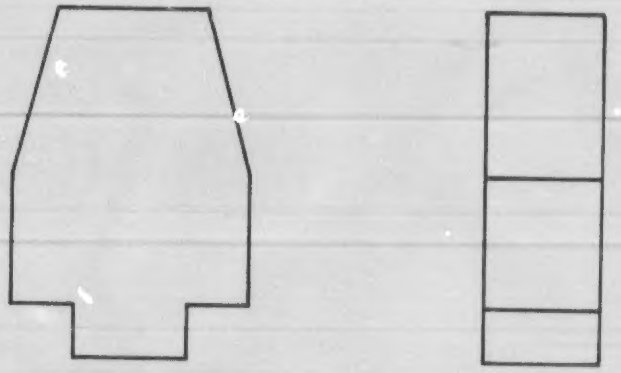
Example:

1. Decide which dimensioning method will be more appropriate to use
2. Add dimension and extension lines as needed
3. Add circular dimension lines if needed

   (NOTE: Use vertex of angle for compass center; circle template is not recommended for this purpose.)
4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

Directions: Dimension the following objects using correct dimensioning procedures. Pay particular attention to dimensioning the angles.

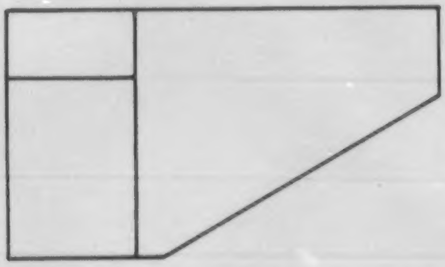
Problem A:



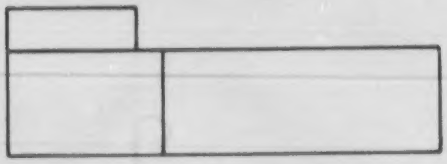
ASSIGNMENT SHEET #4

Directions: Dimension the following objects using correct dimensioning procedures. Add ALL necessary dimensions to describe the object.

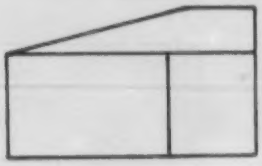
Problem B:



Top



Front

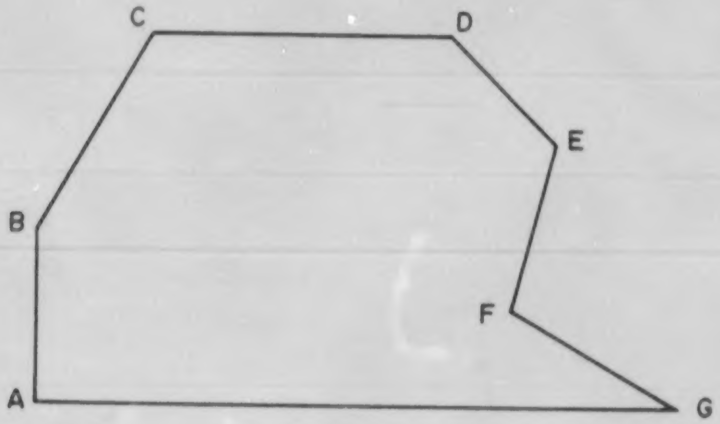


Side

ASSIGNMENT SHEET #4

Directions: Measure and dimension all inside angles in degrees and minutes.

Problem C: Scale 1"=100'



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #5-DIMENSION CURVES

Premise: Curves can be correctly dimensioned by using the procedure in the following example.

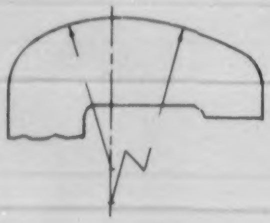
Example:

1. Determine if the curves have all center points given or if they can be located through geometric construction
2. Decide which dimensioning has to be used

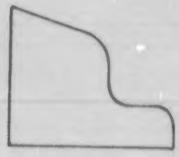
   (NOTE: Refer to objective 26.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following objects using correct dimensioning procedures.

Problem A:

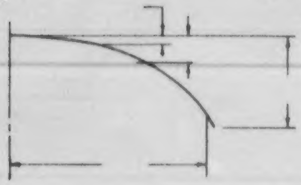


Problem B:



ASSIGNMENT SHEET #5

Problem C:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #6--DIMENSION ROUNDED END SHAPES

Premise: Rounded end shapes can be correctly dimensioned by using the procedure in the following example.

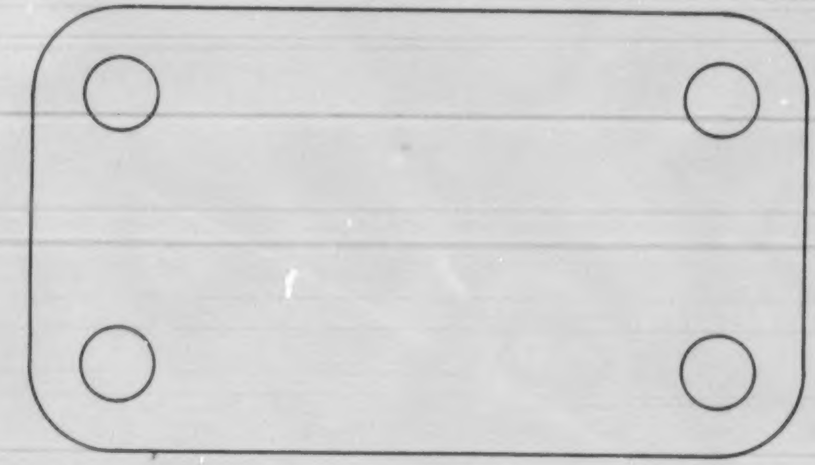
Example:

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

   (NOTE: Refer to objective 27.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

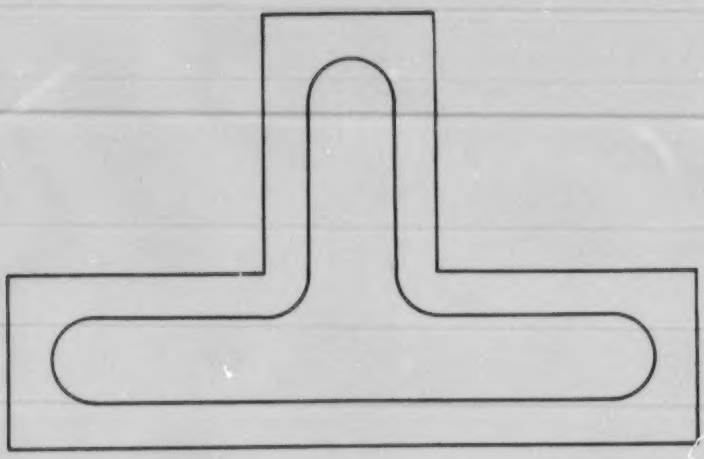
Directions: Dimension the following objects using correct dimensioning procedures.

Problem A:



ASSIGNMENT SHEET #6

Problem B:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #7--DIMENSION SPHERICAL OBJECTS

Premise: Spherical objects can be correctly dimensioned by using the procedure in the following example.

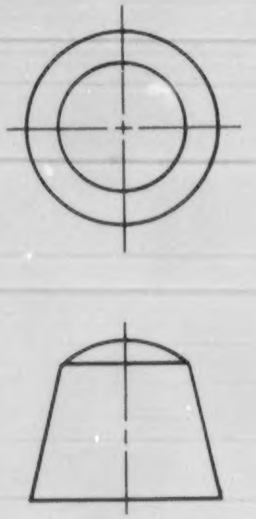
Example:

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

   (NOTE: Refer to objective 28.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

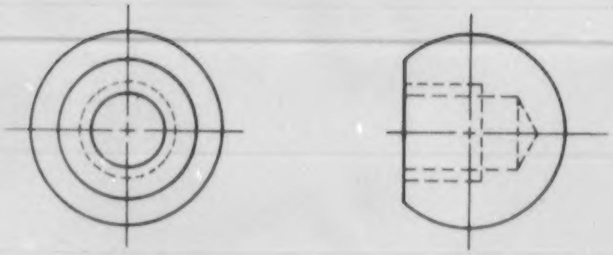
Directions: Dimension the following objects using correct dimensioning procedures.

Problem A:



ASSIGNMENT SHEET #7

Problem B:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #8--DIMENSION CYLINDRICAL OBJECTS

Premise: Cylindrical objects can be correctly dimensioned by using the procedure in the following example.

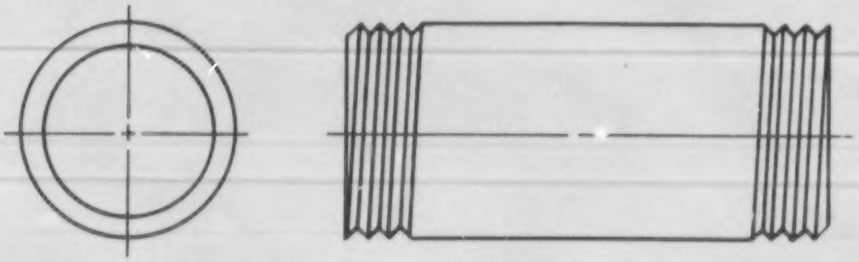
Example:

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

   (NOTE: Refer to objective 29.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following object using correct dimensioning procedures.

Problem:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #9--DIMENSION CONES, PYRAMIDS, AND PRISMS

Premise: Cones, pyramids, and prisms can be correctly dimensioned by using the procedure in the following example.

Example:

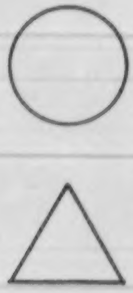
1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

   (NOTE: Refer to objective 30.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

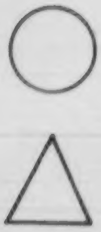
Directions: Dimension the following objects using correct dimensioning procedures.

Problem A: Cones

1. Diameter and height

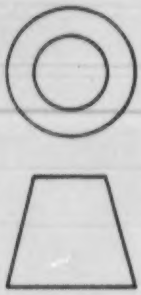


2. Diameter and angle

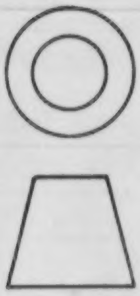


ASSIGNMENT SHEET #9

3. Two diameters and height

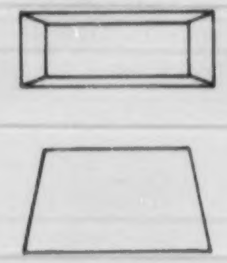


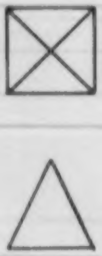
4. Large end diameter height, and taper



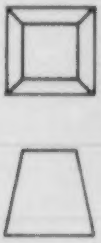
Problem B: Pyramids

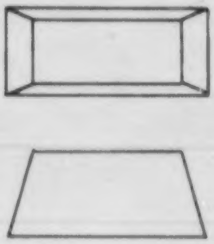
1. Dimensions of base in rectangular view and height in the other view





2. Dimensions of base in square view and center point in rectangular view

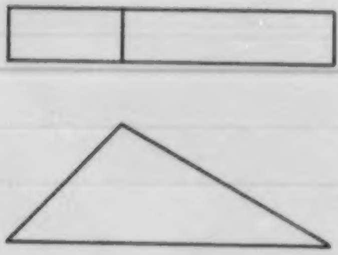




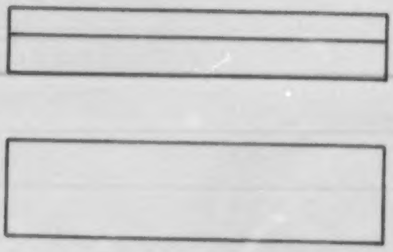
ASSIGNMENT SHEET #9

Problem C: Height, width, and depth of prisms

1.



2.



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #10--DIMENSION FEATURES ON A CIRCULAR CENTER LINE

Premise: Features on a circular center line can be correctly dimensioned by using the procedure in the following example.

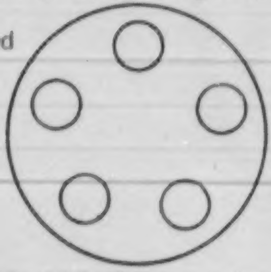
Example:

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

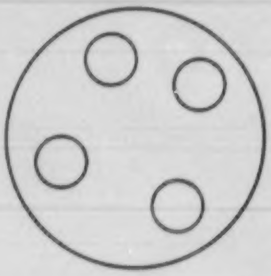
   (NOTE: Refer to objective 31.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following objects using correct dimensioning procedures.

Problem A: Holes equally spaced

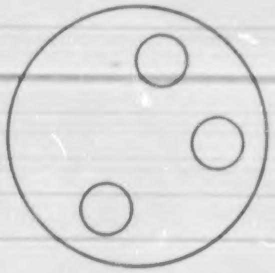


Problem B: Holes unequally spaced indicate angular measurements



ASSIGNMENT SHEET #10

Problem C: Holes unequally spaced; use coordinate dimensions



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #11--DIMENSION A THEORETICAL POINT OF INTERSECTION

Premise: A theoretical point of intersection can be correctly dimensioned by using the procedure in the following example.

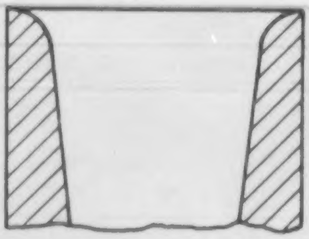
Example:

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Determine what dimensions have to be added

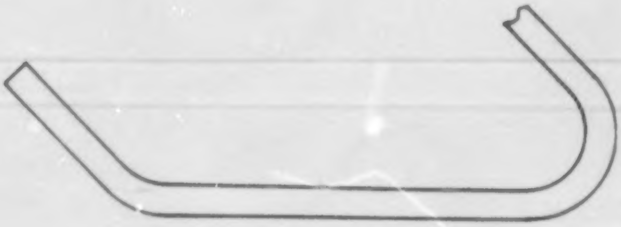
   (NOTE: Refer to objective 32.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following objects using correct dimensioning procedures.

Problem A:

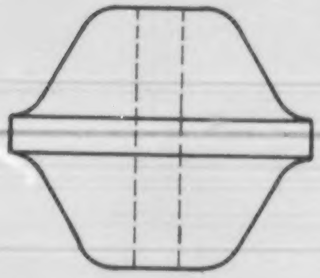


Problem B:



ASSIGNMENT SHEET #11

Problem C:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #12--DIMENSION AN OBJECT USING A RECTANGULAR COORDINATE SYSTEM

Premise: An object can be correctly dimensioned using a rectangular coordinate system by using the procedure in the following example.

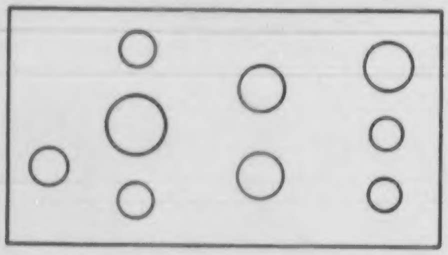
Example:

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

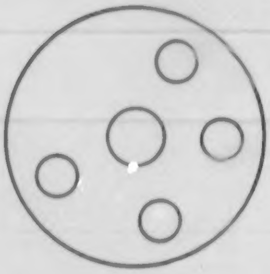
   (NOTE: Refer to objective 36.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following objects using correct dimensioning procedures.

Problem A:



Problem B:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #13--DIMENSION AN OBJECT USING A POLAR COORDINATE SYSTEM

Premise: An object can be correctly dimensioned using a polar coordinate system by using the procedure in the following example.

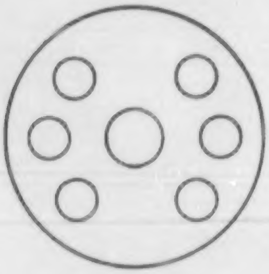
Example:

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added

   (NOTE: Refer to objective 36.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following object using correct dimensioning procedures.

Problem:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #14--DIMENSION AN OBJECT USING A TABULAR COORDINATE SYSTEM

Premise: An object can be correctly dimensioned using a tabular coordinate system by using the procedure in the following example.

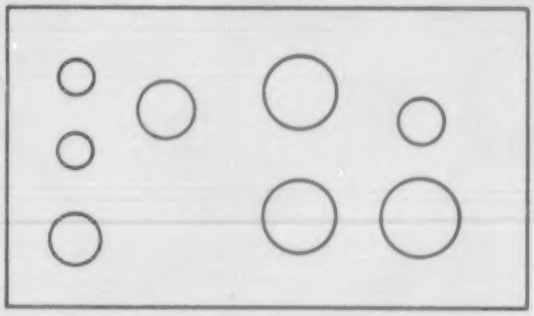
Example:

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensioning has to be used

   (NOTE: Refer to objective 36.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following object using correct dimensioning procedures and properly make a chart.

Problem:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #15--DIMENSION AN OBJECT USING AN ORDINATE DIMENSIONING SYSTEM

Premise: An object can be correctly dimensioned using an ordinate dimensioning system by using the procedure in the following example.

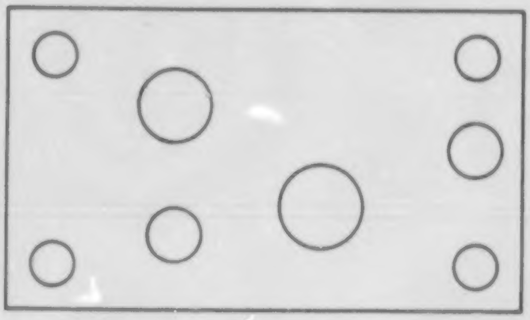
Example:

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensioning has to be used

   (NOTE: Refer to objective 36.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following object using correct dimensioning procedures.

Problem:



DIMENSIONING PROCEDURES
UNIT IV

ASSIGNMENT SHEET #16--DIMENSION AN OBJECT USING PROPER DIMENSIONING RULES AND CORRECT TECHNIQUES TO COMPLETELY DESCRIBE THE OBJECT

Premise: An object can be correctly dimensioned and completely described by using the procedure in the following example.

Example:

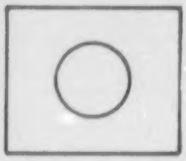
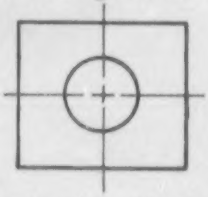
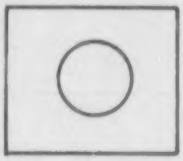
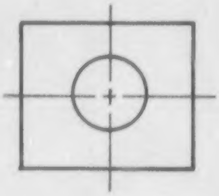
1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide which dimensioning has to be used

   (NOTE: Refer to objectives 37 and 38.)
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

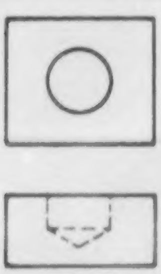
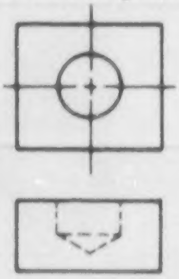
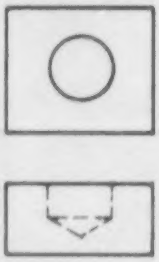
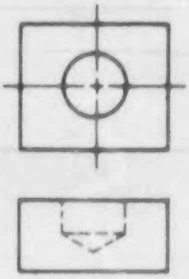
Directions: Dimension the following objects using correct dimensioning procedures.

Problem A: Drill

1. Four methods of dimensioning an all the way through hole

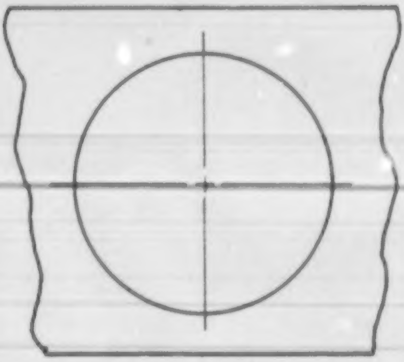





2. Four methods of dimensioning a blind hole

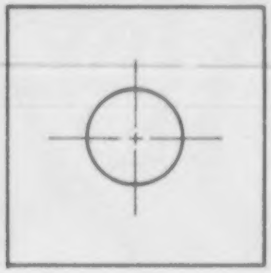





ASSIGNMENT SHEET #16

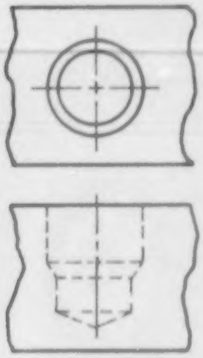
Problem B: 1 1/2" diameter bore



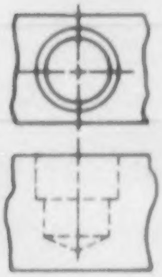
Problem C: 1/2" diameter drill and 9/16" diameter ream



Problem D: Size of counterdrill

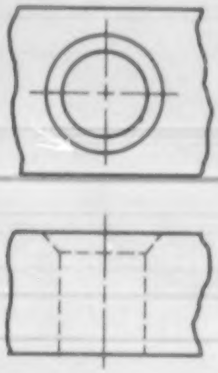


Problem E: Size of counterbore

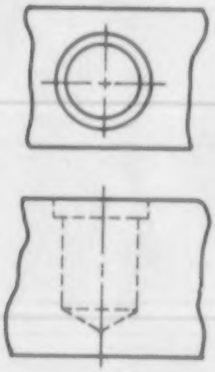


ASSIGNMENT SHEET #16

Problem F: Size of countersink

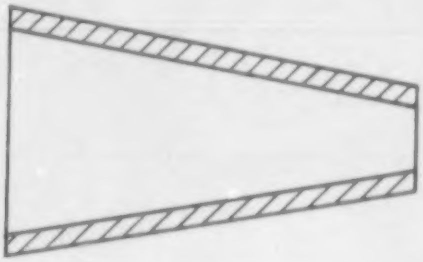


Problem G: Size of spot face

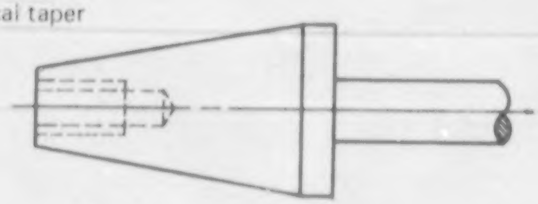


Problem H: Tapers

1. Standard machine taper labeled with an American National Standard taper #4

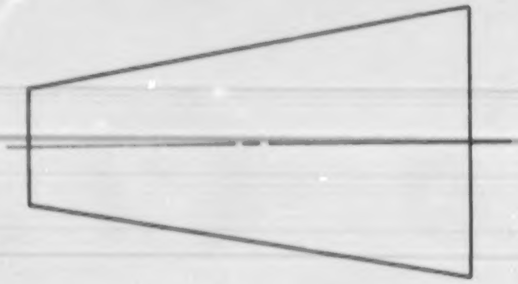


2. Size of non-critical taper

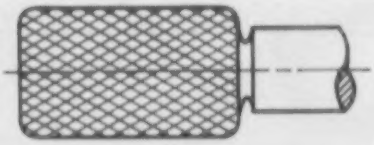


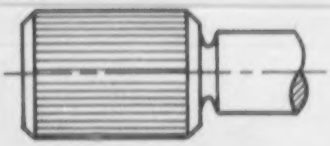
ASSIGNMENT SHEET #16

3. Size of critical taper

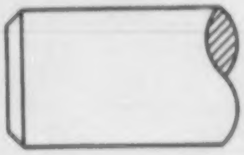


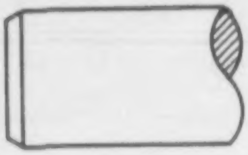
Problem I: Size and type of coarse knurl





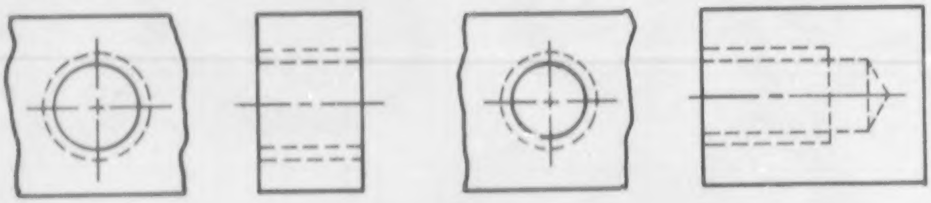
Problem J: Size of metric chamfers





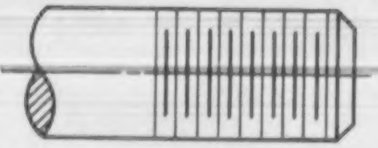
Problem K: Threads

1. Size of internal and external threads

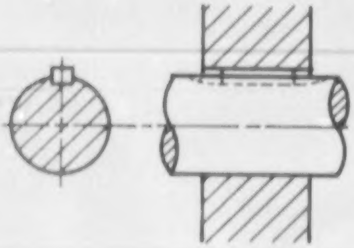


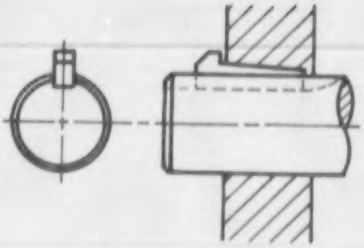
ASSIGNMENT SHEET #16

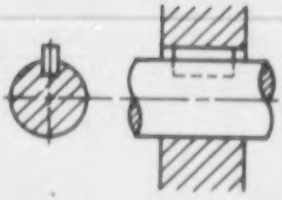
2. Left handed thread



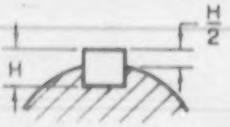
Problem L: Types of keyways

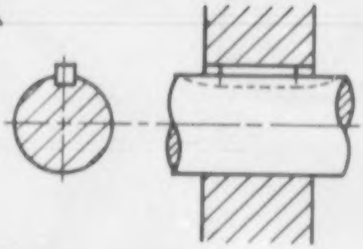


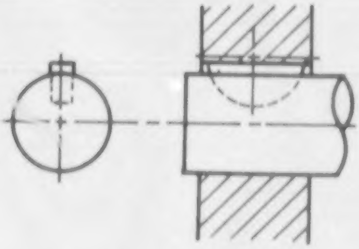




1. ____________________ 2. ____________________ 3. ____________________

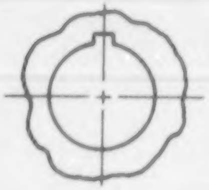






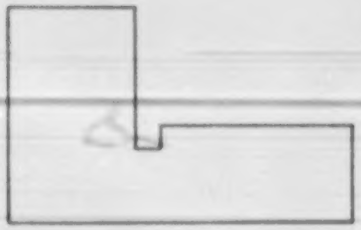
4. ____________________ 5. ____________________

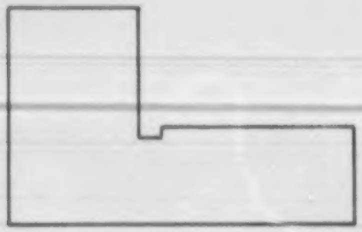
Problem M: Size of keyseat



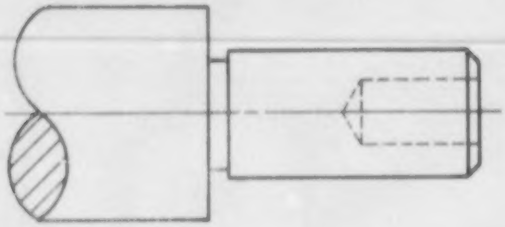
ASSIGNMENT SHEET #16

Problem N: Sizes of relief grooves





Problem O: Size of neck



DIMENSIONING PROCEDURES
UNIT IV

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Exceeding what is sufficient or necessary

_____b. Points, lines, or other geometric shapes assumed to be exact from which the location or geometric features of a part may be established

_____c. Set up in rows and columns, by means of a table

_____d. A dimension used for information purposes only; it does not govern production or inspection operations

_____e. Measured size of a complete object

_____f. A symbol used to indicate a surface to be machined

_____g. A gradual decrease or change of diameter from one end to the other

_____h. A slanted flat surface not at 90° to another surface

_____i. A slight bevel removed from an edge

_____j. A tool with a pointed cutting edge used to make a hole in hard surfaces

_____k. To enlarge a hole with a boring bar or tool in a lathe, drill press, or boring mill

_____l. To enlarge a finished hole slightly to a very precise diameter with a reamer

_____m. A second, larger drill along the same center line as a first drill, but not as deep

_____n. A funnel-like bevel at the surface end of a drilled hole; standard included angle is 82°

_____o. An enlargement of the end of a hole to a specified diameter and depth

1. Tap
2. Drill
3. Counterbore
4. Boss
5. Chamfer
6. Spot face
7. Finish mark
8. Tabular
9. Superfluous
10. Countersink
11. Counterdrill
12. Radial
13. Ream
14. Actual size
15. Datum
16. Bevel
17. Die
18. Nominal
19. Relief groove
20. Reference dimension
21. Blind hole
22. Taper
23. Bore
24. Knurl

______p. A machined circular spot on the surface of a part to provide a flat bearing surface for a bolt head

______q. The process of rolling depressions in the surface of an object

______r. A shallow groove that allows for a thread relief

______s. A hole not drilled all the way through

______t. A tool used to cut internal threads

______u. A tool used to cut external threads

______v. A raised flat, cylindrical surface providing a flat surface for bolts

______w. Moving along a radius

______x. Designated or theoretical size that may vary from the actual

2. Distinguish between size description and shape description by placing an "X" next to the size description.

______a. The views that illustrate the shape of an object

______b. The notes and dimensions that tell the size of an object

3. Differentiate between the types of dimensions in the accompanying illustration by placing an "X" next to the location dimensions.

______a. Dimension A

______b. Dimension B

______c. Dimension C

______d. Dimension D

______e. Dimension E

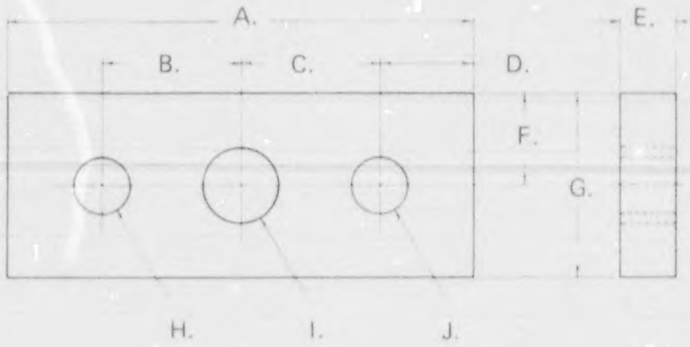
______f. Dimension F

______g. Dimension G

______h. Dimension H

______i. Dimension I

______j. Dimension J



4. Match the systems of placing dimensions on the right with their correct definitions.

_____a. All dimension figures are aligned with the dimension lines so that they may be read from the bottom or from the right side of the sheet

_____b. All dimension figures and notes are lettered horizontally on the sheet and read from the bottom of the drawing

1. Unidirectional system
2. Aligned system

5. Match common abbreviations on the right with their correct meanings.

_____a. American National Standards Institute
_____b. Assembly
_____c. Bevel
_____d. Bill of materials
_____e. Bolt circle
_____f. Cast iron
_____g. Cast steel
_____h. Center line
_____i. Center to center
_____j. Chamfer
_____k. Cold rolled steel
_____l. Counterbore
_____m. Counterdrill
_____n. Countersink
_____o. Degree
_____p. Diameter
_____q. Dimension
_____r. Drawing
_____s. Finish all over
_____t. Inside diameter
_____u. Keyseat

1. CBORE
2. THD
3. MATL
4. DWG
5. CI
6. ASSY
7. CL
8. MIL-STD
9. DIA
10. SF
11. ANSI
12. CHAM
13. TOL
14. BEV
15. ID
16. OD
17. CRS
18. DIM.
19. B/M
20. CDRILL
21. KWY
22. CS
23. SAE

______v. Keyway

______w. Left hand

______x. Material

______y. Military standard

______z. Outside diameter

______aa. Radius

______bb. Society of Automotive Engineers

______cc. Spot faced

______dd. Thread

______ee. Tolerance

24. R
25. CSK
26. KST
27. FAO
28. BC
29. LH
30. C to C
31. DEG

6. Name and define three systems of writing dimensional values.

a. ______________________________

____

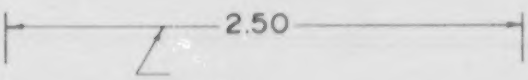
b. ______________________________

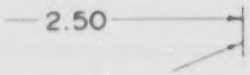
____

c. ______________________________

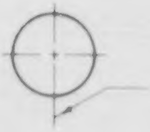
____

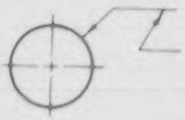
7. Identify four basic types of lines used in dimensioning.





a. ______________________ b. ______________________





c. ______________________ d. ______________________

8. Select true statements concerning rules for lines used in dimensioning by placing an "X" in the appropriate blanks.

______a. Extension lines start or stop 1/16" away from visible lines and are extended approximately 1/8" beyond dimension lines

______b. Extension lines may never cross each other

______c. Extension lines are classified as thin lines

______d. Extension lines may cross dimension lines

______e. Center lines may be used as dimension lines

______f. Dimension lines are classified as thick lines

______g. Dimension lines are broken to allow space for the dimension

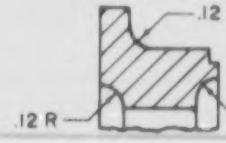
______h. Dimension lines are drawn as arcs to show angular measurement

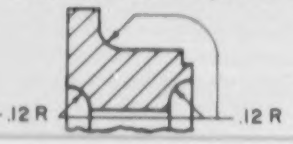
______i. Leaders are usually drawn vertical or horizontal

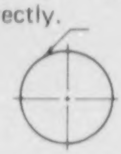
______j. The leader arrowhead touches the arc and points toward the center point

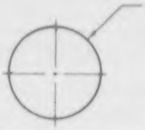
______k. A leader should always point to the middle of a note

9. Differentiate between the correct and incorrect placement of leader lines by placing an "X" next to the leaders that are placed correctly.









a. ____________ b. ____________ c. ______________ d. ____________

10. State how to draw arrowheads.

____

____

11. List two rules concerning arrowheads.

a. ____

b. ____

12. Select true statements concerning rules for dimensional figures by placing an "X" in the appropriate blanks.

______a. All lettering, letters, and numerals must be perfectly legible

______b. Standard height of numerals is 1"

______ c. Fractions are four times the height of whole numbers

______ d. Inch marks (") should always be used

______ e. The fraction bar is always drawn at an angle on a view

______ f. The numerator and denominator of a fraction should touch the fraction bar

______ g. Never letter a dimension figure over any line on the drawing; break the line if necessary

______ h. Make all decimal points bold

______ i. In a group of parallel dimension lines, the numerals should be stacked one above the other

13. State the purpose for using dual dimensioning.

____

____

14. Match the methods of dual dimensioning on the right with their correct definitions.

______ a. The millimeter value is placed above the inch dimension and separated by a dimension line, or an alternative arrangement is to place the millimeter dimension to the left of the inch dimension separated by a slash

______ b. The millimeter dimension is enclosed in square brackets, and the location of this dimension is optional, but should be uniform on any drawing

______ c. One dimension value is given for each dimension on the drawing, and elsewhere on the drawing a conversion table lists in two columns the millimeter values and the inch equivalents

1. Chart method
2. Position method
3. Bracket method

15. Select true statements concerning rules for placement of dimensions by placing an "X" in the appropriate blanks.

______ a. Each dimension should be given clearly so that it can be interpreted in only one way

______ b. Dimensions may be duplicated at any time

______ c. Dimensions should be given between points or surfaces that have a functional relation to each other or that control the location of mating parts ______d. Dimensions should be given to finished surfaces or important center lines in preference to rough surfaces wherever possible

______e. Dimensions do not need to be complete enough for a machinist

______f. Dimensions should be drawn to hidden lines wherever possible

______g. Dimensions applying to two adjacent views should be placed between views unless clearness is promoted by placing some of them outside

______h. Do not expect the worker to assume that a feature is centered (as a hole on a plate), but give a location dimension from one side

______i. Horizontal and vertical center lines should not be used as reference lines for dimensions

16. Arrange in order the steps in applying dimensions to an object by placing the correct sequence numbers in the appropriate blanks.

______a. Draw in arrowheads

______b. Draw extension lines and extend the center lines of the hole to be used in the same manner as extension lines

______c. Draw in guidelines for figures

______d. Letter in dimensions

______e. Use scale to measure dimension line locations with adequate space between each and gaps for dimension figures

17. State the purpose of finish marks.

____

18. Draw four types of finish marks.

a. ____________________________ b. ____________________________

c. ____________________________ d. ____________________________

19. Select true statements concerning rules for finish marks by placing an "X" in the appropriate blanks.

______a. Finish marks should be placed on the edge views of all finished surfaces, including hidden edges and the contour and circular views of cylindrical surfaces

______b. Finish marks should be used on holes and other features where a note specifies a machining operation ______c. Finish marks should always be used on parts made from rolled stock

______d. If a part is finished all over, omit all finish marks, and use the following general note: FINISH ALL OVER, or FAO

20. State the purpose for a notation on a drawing.

____

21. Select true statements concerning rules for notations by placing an "X" in the appropriate blanks.

______a. Notes are always placed parallel to the side of the drawing

______b. Notes should be brief and clear and contain only pertinent data

______c. Notes should be spaced far enough from the views not to crowd, but still close enough to eliminate the need for a long leader

______d. Notes should always be composed so that the various shop operations are listed in the order in which they should be performed

______e. Use lower case letters for all notes on machine drawings

22. Name and define the two types of notes used on a drawing.

a. ____

____

b. ____

____

23. Select true statements concerning rules for dimensioning common machine manufactured features.

______a. "R" follows all radii dimensions; the center is shown by a cross and only one arrowhead is used; available space determines whether the dimension figure goes inside or outside the arc

______b. A circle is always dimensioned by its radius

______c. A metric diameter dimension value should be preceded by the symbol Ø and the diameter dimension value in inches should be followed by DIA except when either dimension is obviously a diameter

______d. Cylinders should be located by their radius

______e. Drill sizes are preferably expressed in fractions

______f. Cylinders should be located in the circular views, if possible _____g. Cylinders should always be located by angular dimensions where accuracy is important

_____h. When a dimension is not to scale, it should be underscored with a bold straight line

_____i. Decimal dimensions should be used when accuracy greater than 1" is required on a machine dimension

24. Select true statements concerning methods of dimensioning arcs in available spaces by placing an "X" in the appropriate blanks.

_____a. An arc is dimensioned in the view in which its true shape is shown

_____b. A center cross can be omitted for all center points

_____c. In least limited space, move figure and arrowhead outside

_____d. In most limited space, move figure and arrowhead outside

25. Draw an illustration that shows how to correctly dimension angles.

26. Draw an illustration that shows how to correctly dimension curves.

27. Draw an illustration that shows how to correctly dimension rounded end shapes.

28. Draw an illustration that shows how to correctly dimension a spherical object.

29. Draw an illustration that shows how to correctly dimension cylindrical objects.

30. Draw three illustrations that show how to correctly dimension cones, pyramids, and prisms.

31. Draw an illustration that shows how to correctly dimension features on a circular center line.

32. Draw an illustration that shows how to correctly dimension a theoretical point of intersection.

33. State two reasons for avoiding superfluous dimensions.

a. ____________________

b. ____________________

34. List three ways to avoid superfluous dimensions.

a. ____________________

b. ____________________

c. ____________________

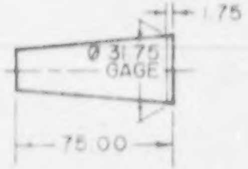
35. List two factors concerning mating dimensions.

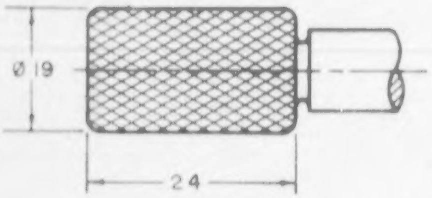
a. ____________________

b. ____________________

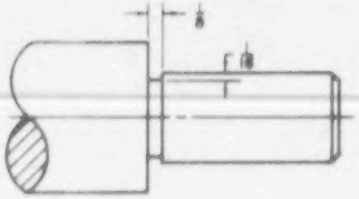
36. Draw an illustration that shows how to dimension an object using the rectangular coordinate system.

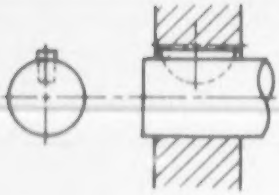
37. Identify various standard machine manufactured features.


1.75
Ø 31.75
GAGE
75.00

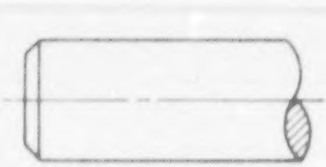


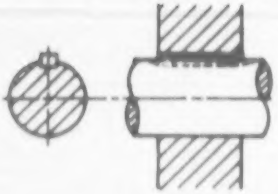
a. ______________________ b. ______________________





c. ______________________ d. ______________________

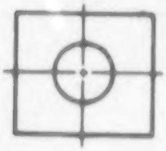




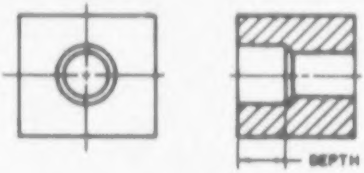
e. ______________________ f. ______________________

38. Write proper dimension notes for standard machine manufactured features.

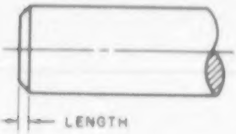
a. Ream--Drilled to .20, reamed to .2415



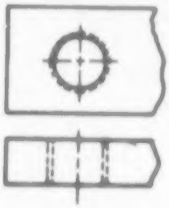
b. Counterdrill-Diameter of second drill, 3/4 and 7/16 deep; diameter of first drill, 1/2



c. Chamfer--Length of offset, 1/16; 45°



d. Internal thread, through-drill--
   1) 7/8-fractional size of tap drill
   2) 3/4 - Nominal thread diameter
   3) 1 - Class 1 thead fit
   4) UN - Unified thread fit
   5) 12 - Threads per inch
   6) F - Fine thread series



39. Demonstrate the ability to:

a. Construct arrowheads.

b. Dimension arcs.

c. Dimension angles.

d. Dimension curves.

e. Dimension rounded end shapes.

f. Dimension spherical objects.

g. Dimension cylindrical objects.

h. Dimension cones, pyramids, and prisms.

i. Dimension features on a circular center line.

j. Dimension a theoretical point of intersection.

k. Dimension an object using a rectangular coordinate system.

l. Dimension an object using a polar coordinate system.

m. Dimension an object using a tabular coordinate system.

n. Dimension an object using an ordinate dimensioning system.

o. Dimension an object using proper dimensioning rules and correct techniques to completely describe the object.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DIMENSIONING PROCEDURES
UNIT IV

ANSWERS TO TEST

1. a. 9
   b. 15
   c. 8
   d. 20
   e. 14
   f. 7
   g. 22
   h. 16
   i. 5
   j. 2
   k. 23
   l. 13
   m. 11
   n. 10
   o. 3
   p. 6
   q. 24
   r. 19
   s. 21
   t. 1
   u. 17
   v. 4
   w. 12
   x. 18

2. b

3. b, c, d, f

4. a. 2
   b. 1

5. a. 11
   b. 6
   c. 14
   d. 19
   e. 28
   f. 5
   g. 22
   h. 7
   i. 30
   j. 12
   k. 17
   l. 1
   m. 20
   n. 25
   o. 31
   p. 9
   q. 18
   r. 4
   s. 27
   t. 15
   u. 26
   v. 21
   w. 29
   x. 3
   y. 8
   z. 16
   aa. 24
   bb. 23
   cc. 10
   dd. 2
   ee. 13

6. a. Fractional--System of units and common fractions used primarily in structural work

   b. Decimal--System of units and decimals used in machine drawing where extreme accuracy is required

   c. Metric--System of units and decimals based on "The International System of Units", where the millimeter is the linear unit of measure

7. a. Dimension line
   b. Extension line
   c. Center line
   d. Leader line

8. a, c, g, h, j

9. a, d

10. Arrowheads are drawn with two sharp strokes toward or away from the point; length will vary depending on size of drawing, but width should always be 1/3 of the length

11. a. Arrowheads always touch extension lines

    b. Arrowheads are reversed when space for the dimension is too small

12. a, g, h

13. To show dimensions in millimeters and inches; it is especially applicable to the manufacture of interchangeable parts on an international basis

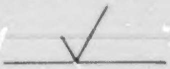
14. a. 2
    b. 3
    c. 1

15. a, c, d, g, h

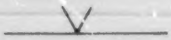
16. a. 3
    b. 1
    c. 4
    d. 5
    e. 2

17. To indicate a surface on an object that is to be finished or machined

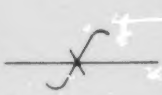
18. a.



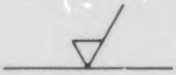
b.



c.



d.



19. a, d

20. To provide in concisely worded statements information that cannot be given by standard dimensions

21. b, c, d

22. a. General note--Consists of information which applies to the entire drawing

    b. Local (specific) note--Refers to one particular feature and requires the use of a leader

23. a, c, f

24. a, d

25-32. Evaluated to the satisfaction of the instructor

33. a. Duplication of effort

    b. Increased chance of error for drafter and workers

34. Any three of the following:

    a. Give dimensions in the most direct and simple way

    b. Always dimension to shop operation requirements

    c. Never give a dimension more than once in the same view or in different views

    d. Remember that the worker should never have to do any calculations from a drawing to find a necessary dimension

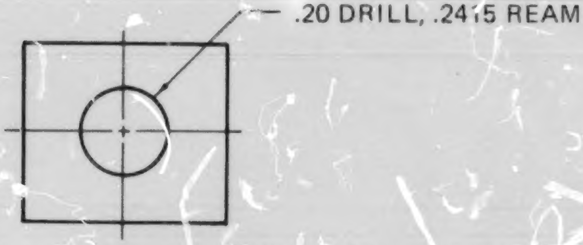
35. a. On two mating parts certain dimensions must correspond to make the parts fit together; these are mating dimensions

b. While the base size will remain the same, the actual values of two corresponding mating dimensions may not be exactly the same because the difference will depend on the accuracy of fit required

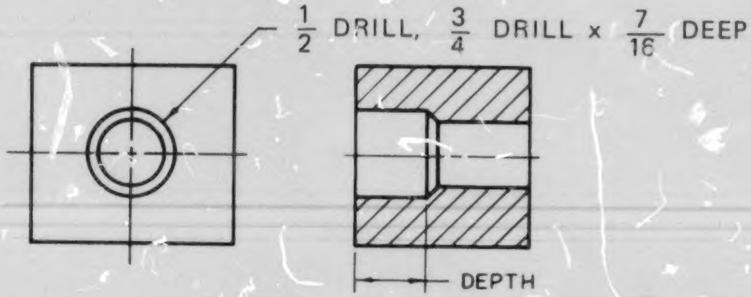
36. Evaluated to the satisfaction of the instructor

37. a. Taper
   b. Diamond pattern knurl
   c. Neck
   d. Woodruff key
   e. Chamfer
   f. Flat key

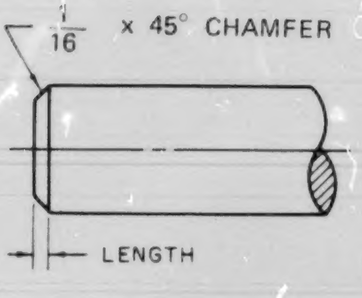
38. a.


.20 DRILL, .2415 REAM

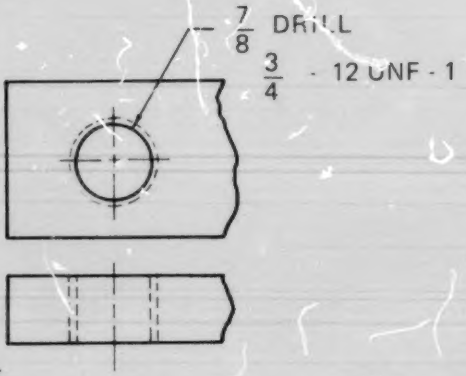
b.


1/2 DRILL, 3/4 DRILL x 7/16 DEEP
DEPTH

c.


1/16 x 45° CHAMFER
LENGTH

d.


7/8 DRILL
3/4 - 12 UNF - 1

39. Evaluated to the satisfaction of the instructor

BASIC TOLERANCING
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to illustrate dimensioning tolerances on drawings. The student should also be able to determine clearance fits, interference fits, transition fits, and assign tolerances from standard fit tables to drawings. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to basic tolerancing with their correct definitions.
2. Illustrate the systems of dimensioning tolerances on drawings.
3. List the general types of fits.
4. Complete a chart of standard fits.
5. Determine clearance fit tolerance of mating parts using standard fit tables.
6. Determine interference fit tolerance of mating parts using standard fit tables.
7. Determine the limit dimensions of mating parts using standard fit tables.
8. Distinguish between the types of dimensioning systems.
9. Demonstrate the ability to:
    a. Interpret decimal tolerance dimensions.
    b. Calculate and dimension clearance fit tolerances of mating parts.
    c. Calculate and dimension interference fit tolerances of mating parts.
    d. Calculate and assign tolerances to mating parts using standard fit tables.
    e. Construct a drawing using datum dimensioning.

BASIC TOLERANCING
UNIT V

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Show available standard fit tables from *Machinery's Handbook* or textbook appendixes and discuss how to use the tables.

VII. Provide part drawings which include specified tolerances.

VIII. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Tolerances
    2. TM 2--Application of Dimensioning
    3. TM 3--Types of Fits
    4. TM 4--Types of Dimensioning Systems

  D. Assignment sheets

    1. Assignment Sheet #1--Interpret Decimal Tolerance Dimensions
    2. Assignment Sheet #2--Calculate and Dimension Clearance Fit Tolerances of Mating Parts
    3. Assignment Sheet #3--Calculate and Dimension Interference Fit Tolerances of Mating Parts
    4. Assignment Sheet #4--Calculate and Assign Tolerances to Mating Parts Using Standard Fit Tables
    5. Assignment Sheet #5--Construct a Drawing Using Datum Dimensioning

   E. Answers to assignment sheets

   F. Test

   G. Answers to test

II. References:

A. Giesecke, Frederick E., et al. *Technical Drawing.* New York, NY 10022: Macmillan Publishing Co., Inc., 1980.

B. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

C. Oberg, Erik and F.D. Jones. *Machinery's Handbook.* New York, NY 10016: Industrial Press, Inc., 1978.

D. American Society of Mechanical Engineers. *ANSI Engineering Drawing and Related Documentation Practices.* New York, NY 10017, 1979.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

BASIC TOLERANCING
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Tolerancing--System designed to control dimensions to allow interchangeability in manufacturing

B. Interchangeability--The condition that refers to a part made to limit dimensions so that it will fit any part similarly manufactured

C. Basic dimension--A theoretically exact value used to describe the size, shape, or location of a feature

(NOTE: Basic dimensions are indicated on the drawing by the word BASIC or the abbreviation BSC.)

D. Feature--A portion of a part, such as a diameter, hole, keyway, or flat surface

E. Reference dimension--Untoleranced dimensions placed on drawings for the convenience of engineering and manufacturing

(NOTE: Reference dimensions are indicated by the abbreviation REF.)

F. Datums--Points, lines, or other geometric shapes assumed to be exact from which the location or geometric form of features of a part may be established

G. Nominal size The classification size given to manufactured products such as pipe or lumber

(NOTE: It may or may not indicate exact size of the product.)

H. Basic size--The size of a part determined by engineering and design requirements from which the limits of size are determined

I. Actual size--The measured size of an object

J. Allowance--The minimum intentional difference in the dimensions of mating parts to provide for different classes of fits

K. Fit--Degree of tightness or looseness between mating parts

L. Design size--The size of a feature after an allowance for clearance has been applied and tolerances have been assigned

INFORMATION SHEET

M. Limits--The extreme permissible dimensions of a part resulting from the application of a tolerance

N. Tolerance--The total amount of variation permitted in limit dimension of a part

O. Variation--The extent to which or the range in which a dimension or size varies

P. Unilateral tolerance--The variation is in only one direction from the specified dimensions

Q. Bilateral tolerance--The variations permitted are in both directions from the specified dimensions

R. Clearance fit--Limits of size are determined so that a positive allowance or loose fit occurs between mating parts

S. Interference fit–Limits of size are determined so that a negative allowance or tight fit occurs between mating parts

T. Transition fit--Limits of size are determined so that the allowance may be either a clearance fit or an interference fit

U. Dimension--Measurements given on a drawing such as size and location

V. Limit dimensioning--Method of dimensioning where only the maximum and minimum dimensions are given

W. Chain dimensioning--Successive dimensions that extend from one feature to another, rather than each originating at a datum

(NOTE: Tolerances accumulate with chain dimensions unless the note, "Tolerances do not accumulate," is placed on the drawing.)

X. Datum dimensioning--Method where features are dimensioned individually from a datum

(NOTE: System does not accumulate tolerances or dimensions from feature to feature.)

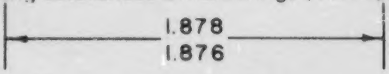
Y. Basic shaft system--The basic size of the shaft is the design size and the allowance is applied to the hole

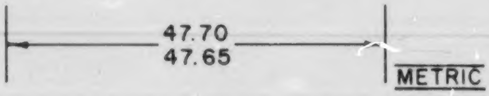
Z. Basic hole system--The basic size of the hole is the design size and the allowance is applied to the shaft

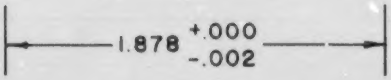
INFORMATION SHEET

II. Systems of dimensioning tolerances on drawings (Transparencies 1 and 2)

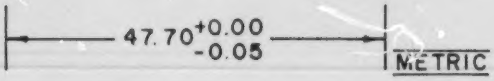
A. Limits



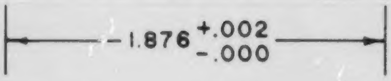

47.70
47.65
METRIC


1.878 +.000 -.002

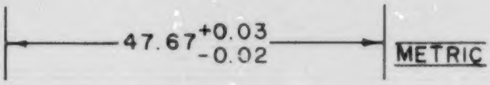
B. Plus and minus


47.70 +0.00 -0.05
METRIC

1. Unilateral


1.876 +.002 -.000

2. Bilateral


47.67 +0.03 -0.02
METRIC

C. Notes

(NOTE: In cases where all tolerances are the same, it is more convenient to list the information in a note than to list the tolerances separately.)

Example: Note: Tolerances are ± .010 unless otherwise specified.

III. General types of fits (Transparency 3)

A. Clearance

B. Interference

C. Transition

INFORMATION SHEET

IV. Chart of standard fits

LETTER SYMBOL	CLASS NAME	DESIGNED USE
Running and Sliding Fits		
RC1	Close sliding fit	Parts that will assemble without play
RC2	Sliding fit	Greater clearance than RC1
RC3	Precision running fits	Close fits for slow speeds and light shaft pressure
RC4	Close running fit	Accurate machinery with moderate surface speeds
RC5 & RC6	Medium running fit	High running speeds or heavy shaft pressures
RC7	Free running fit	Accuracy is not essential or where large temperature variations exist
RC8 & RC9	Loose running fit	Wide commercial tolerances if needed
Locational Fits		
LC1 thru LC11	Locational clearance fits	Parts which can be freely assembled or disassembled
LT1 thru LT6	Locational transition fits	Medium fit between clearance and interference fit
LN1 thru LN3	Locational interference fits	Provides accuracy of location for parts requiring rigidity and alignment
Force Fits		
FN 1	Light drive fits	Parts requiring light assembly pressures
FN2	Medium drive fits	For ordinary steel parts or shrink fits on light sections
FN3	Heavy drive fits	Heavier steel parts or shrink fits in medium sections
FN4 & FN5	Force fits	Parts which can be highly stressed

INFORMATION SHEET

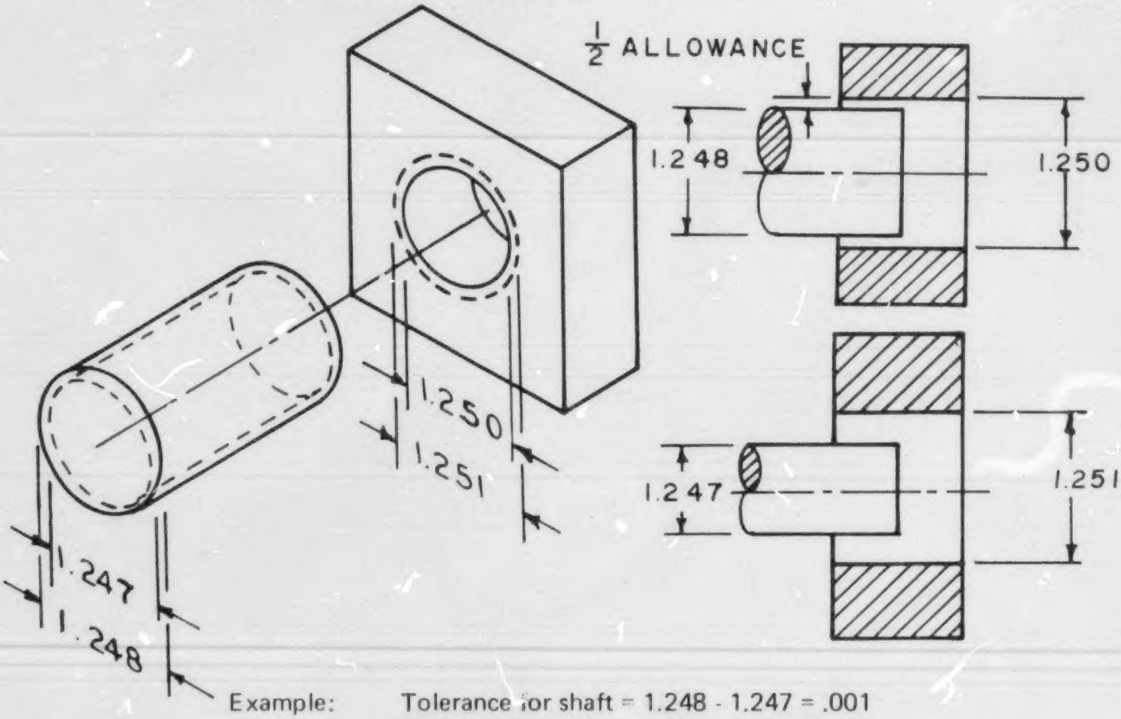
V. How to determine the clearance fit tolerance of mating parts

A. Determine tolerance for shaft

B. Determine tolerance for hole

C. Determine allowance

D. Determine maximum clearance



Example: Tolerance for shaft = 1.248 - 1.247 = .001
Tolerance for hole = 1.251 - 1.250 = .001
Allowance = 1.250 smallest hole diameter limit
- 1.248 largest shaft diameter limit
= .002
Maximum clearance = 1.251 largest hole diameter limit
- 1.247 smallest shaft diameter limit
= .004

(NOTE: Allowance is the minimum clearance of mating parts.)

INFORMATION SHEET

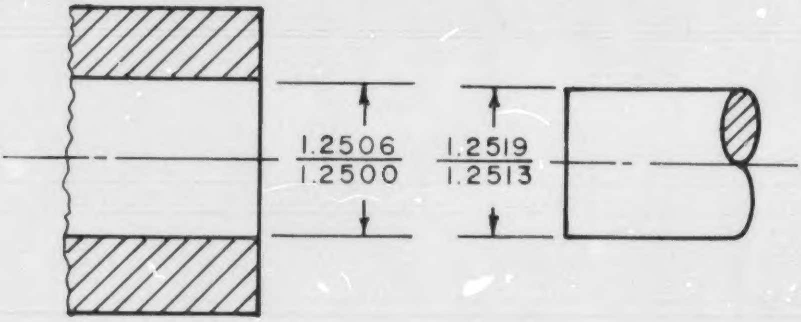
VI. How to determine the interference fit tolerance of mating parts

A. Determine tolerance for shaft

B. Determine tolerance for hole

C. Determine interference

D. Determine maximum interference



Example:		
	Tolerance for shaft	= 1.2519 - 1.2513 = .0006
	Tolerance for hole	= 1.2506 - 1.2500 = .0006
	Interference	= 1.2513 smallest shaft diameter limit - 1.2506 largest hole diameter limit = .0007
	Maximum interference	= 1.2519 largest shaft diameter limit - 1.2500 smallest hole diameter limit = .0019

INFORMATION SHEET

VII. How to determine the limit dimensions of mating parts from standard fit tables

Running and sliding fits									
Nominal Size Range inches	Class RC 1			Class RC 2			Class RC 3		
	Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits	
Over To		Hole H5	Shaft g4		Hole H6	Shaft g5		Hole H7	Shaft f6
0-0.12	0.1 0.45	+0.2 -0	-0.1 -0.25	0.1 0.55	+0.25 -0	-0.1 -0.3	0.3 0.95	+0.4 -0	-0.3 -0.55
0.12-0.24	0.15 0.5	+0.2 -0	-0.15 -0.3	0.15 0.65	+0.3 -0	-0.15 -0.35	0.4 1.12	+0.5 -0	-0.4 -0.7
0.24-0.40	0.2 0.6	+0.25 -0	-0.2 -0.35	0.2 -.85	+0.4 -0	-0.2 -0.45	0.5 1.5	0.6 -0	-0.5 -0.9
0.40-0.71	0.25 0.75	+0.3 -0	-0.25 -0.45	0.25 0.95	+0.4 -0	-0.25 -0.55	0.6 1.7	+0.7 -0	-0.6 -1.0
0.71-1.19	0.3 0.95	+0.4 -0	-0.3 -0.55	0.3 1.2	+0.5 -0	-0.3 -0.7	0.8 2.1	+0.8 -0	-0.8 -1.3
1.19-1.97	0.4 1.1	+0.4 -0	-0.4 -0.7	0.4 1.4	+0.6 -0	-0.4 -0.8	1.0 2.6	+1.0 -0	-1.0 -1.6
1.97-3.15	0.4 1.2	+0.5 -0	-0.4 -0.7	0.4 1.6	+0.7 -0	-0.4 -0.9	1.2 3.1	+1.2 -0	-1.2 -1.9

(NOTE: From ANSI B4.1-1967, R1974. For larger diameters and other tables see the standards, appendixes in drafting textbooks, or *Machinery's Handbook.*)

A. To conserve space, all values for limits of holes and shafts in standard fit tables are expressed in thousandths of an inch

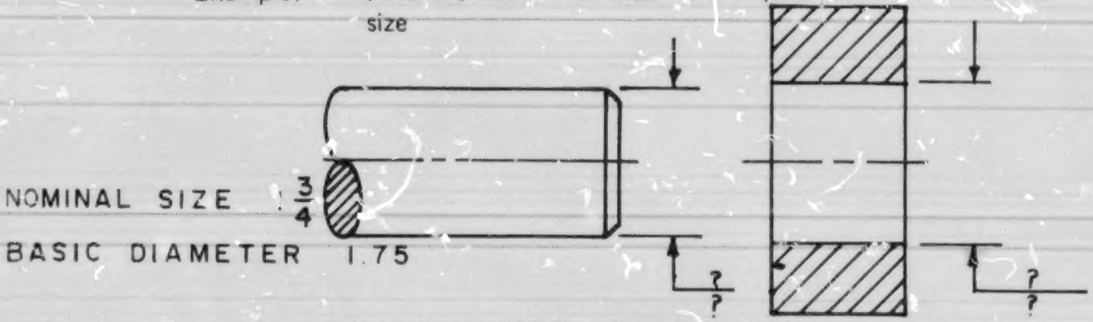
Example: Reading of +0.2 would be plus two ten-thousandths of an inch (+.0002); -1.4 would be read as minus fourteen ten-thousandths (-.0014).

(NOTE: These may be converted by multiplying by one thousandth; therefore, +0.6 x .001 = +.0006.)

INFORMATION SHEET

B. How to use the standard fit table to determine tolerance

Example: Find the limits if an RC2 fit is required for 1 3/4" nominal size



1. Locate the RC2 fit column in the table

2. Find the nominal size range of the hole and shaft; 1.750 falls between 1.19 - 1.97

3. Read across to the RC2 column

4. From the limits given for the hole (+0.6 and 0), and shaft (-0.4 and-0.8), add and subtract these to the basic size

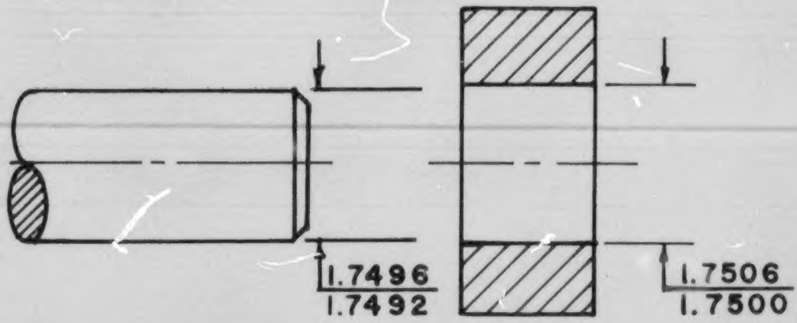
5. Assign limit dimensions to drawings

SHAFT

$$\begin{array}{r} 1.7500 \\ -\ .0004 \\ \hline 1.7496 \end{array} \qquad \begin{array}{r} 1.7500 \\ -\ .0008 \\ \hline 1.7492 \end{array}$$

HOLE

$$\begin{array}{r} 1.7500 \\ +\ .0006 \\ \hline 1.7506 \end{array} \qquad \begin{array}{r} 1.7500 \\ -\ .0000 \\ \hline 1.7500 \end{array}$$



C. How to check limits of clearance or interference of fits after calculations have been made

Example:

1. Allowance = 1.7500 - 1.7496 = .0004 = 0.4
   Maximum clearance = 1.7506 - 1.7492 = .0014 = 1.4

2. Read from RC2 limits of clearance table; 0.4 and 1.4

3. Calculations are correct

INFORMATION SHEET

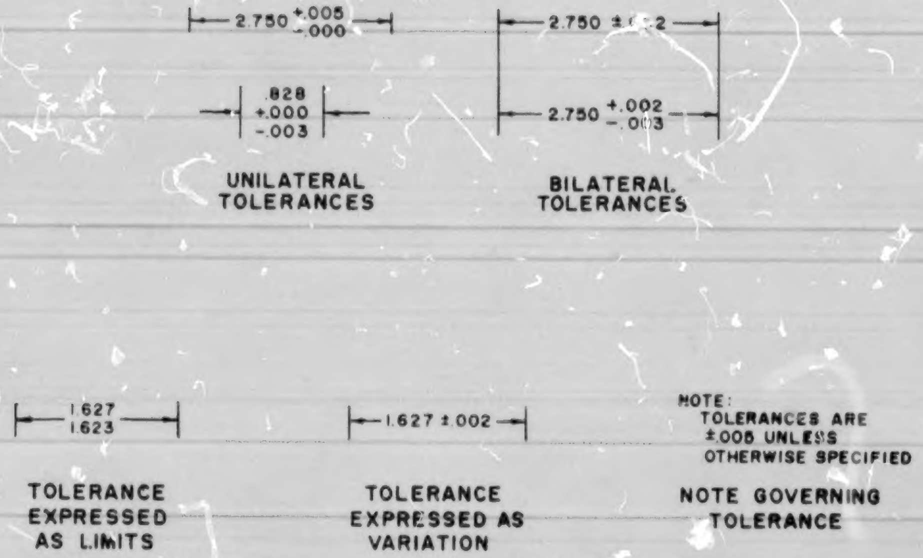
VIII. Types of dimensioning systems (Transparency 4)

A. Chain–Features are dimensioned from point to point, such as holes, and may accumulate tolerances that exceed specifications

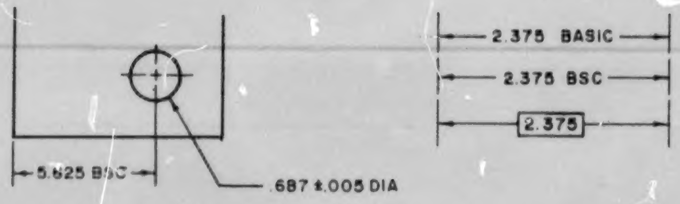
(NOTE: This is not normally used.)

B. Datum--Features are dimensioned individually from a datum or zero line and avoids accumulation of tolerances

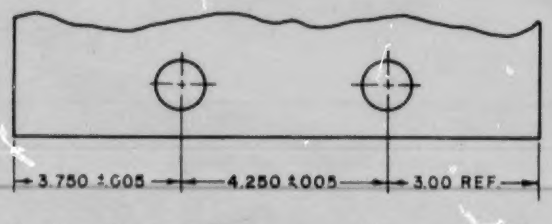
Types of Tolerances


2.750 +.005 -.000
.828 +.000 -.003
UNILATERAL TOLERANCES
2.750 ±.002
2.750 +.002 -.003
BILATERAL TOLERANCES
1.627 1.623
TOLERANCE EXPRESSED AS LIMITS
1.627 ±.002
TOLERANCE EXPRESSED AS VARIATION
NOTE: TOLERANCES ARE ±.005 UNLESS OTHERWISE SPECIFIED
NOTE GOVERNING TOLERANCE

Indicating tolerances on drawings

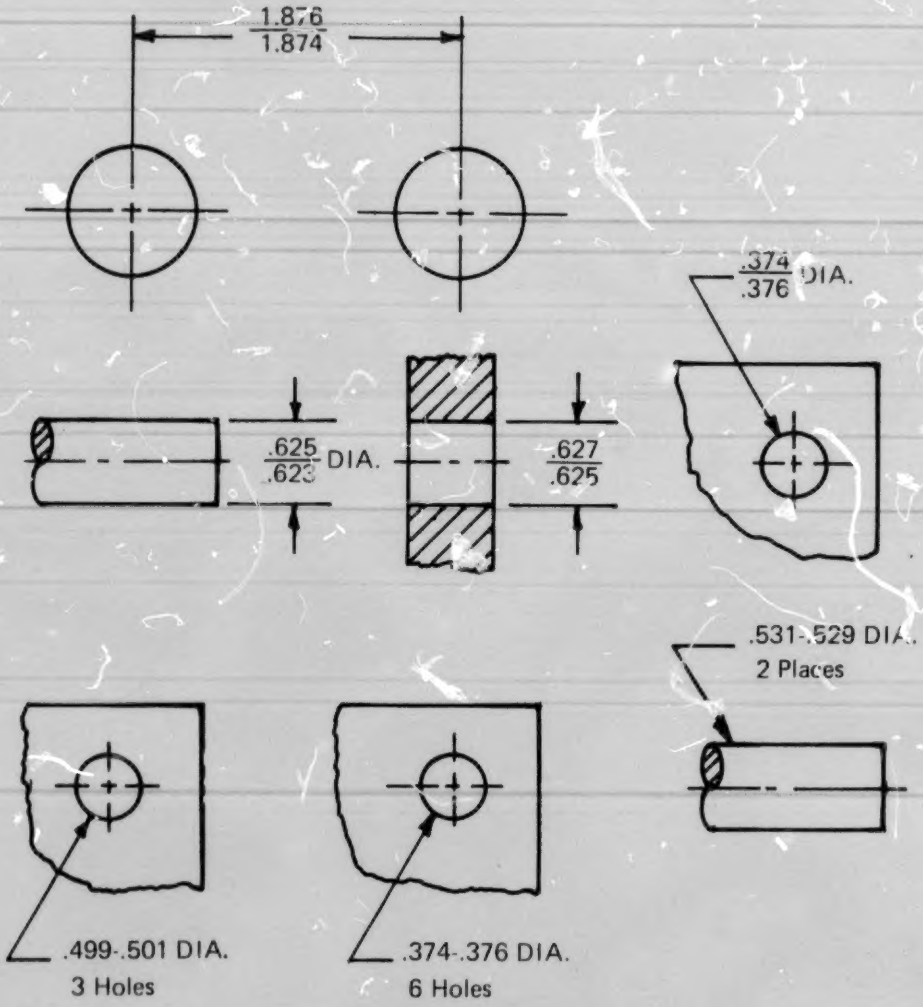

5.625 BSC
.687 ±.005 DIA
2.375 BASIC
2.375 BSC
2.375

Indicating BASIC dimensions

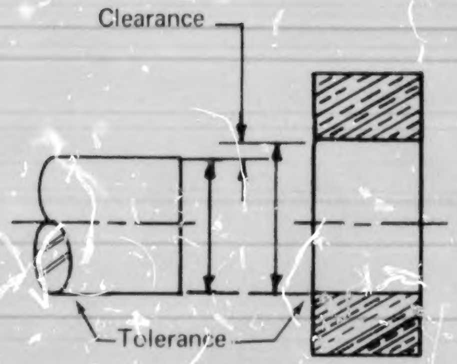

3.750 ±.005
4.250 ±.005
3.00 REF.

Indicating reference dimensions

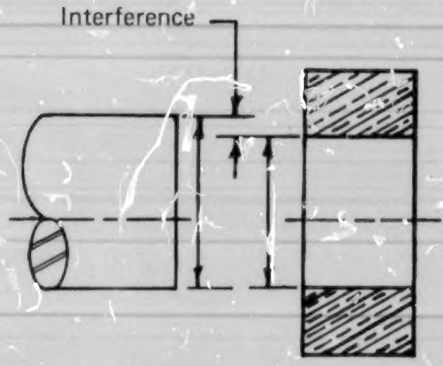
Application of Dimensioning


1.876
1.874
.374
.376 DIA.
.625
.623 DIA.
.627
.625
.531-.529 DIA.
2 Places
.499-.501 DIA.
3 Holes
.374-.376 DIA.
6 Holes

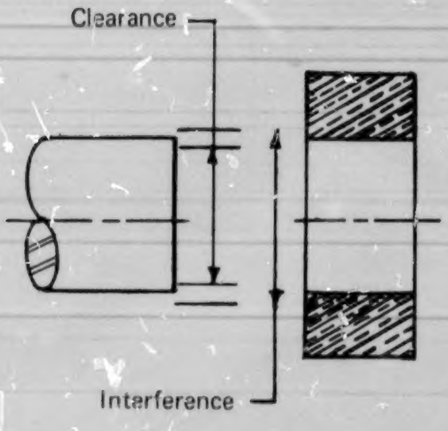
Types of Fits


Clearance
Tolerance

Clearance Fit

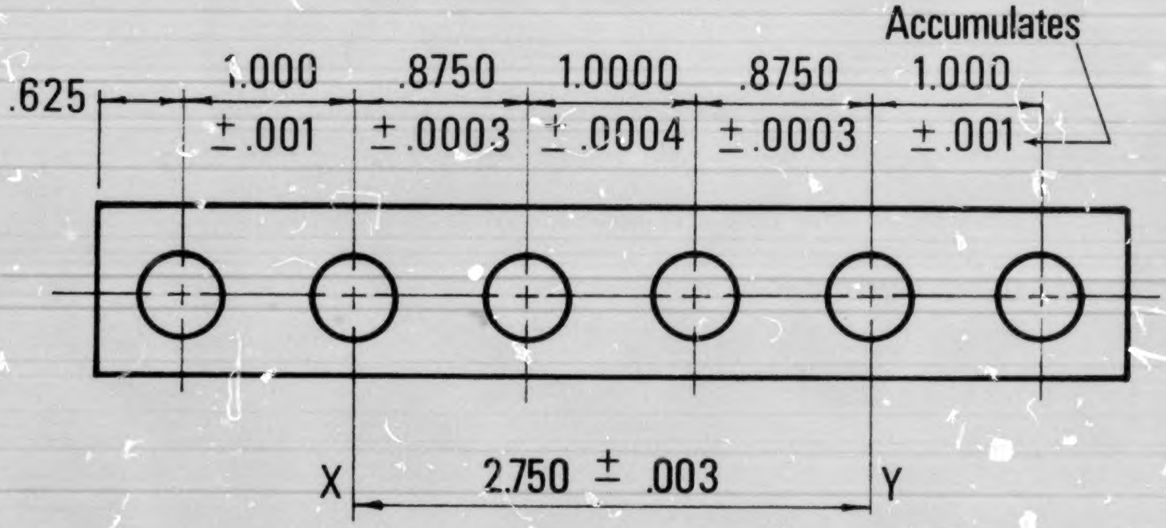

Interference

Interference Fit

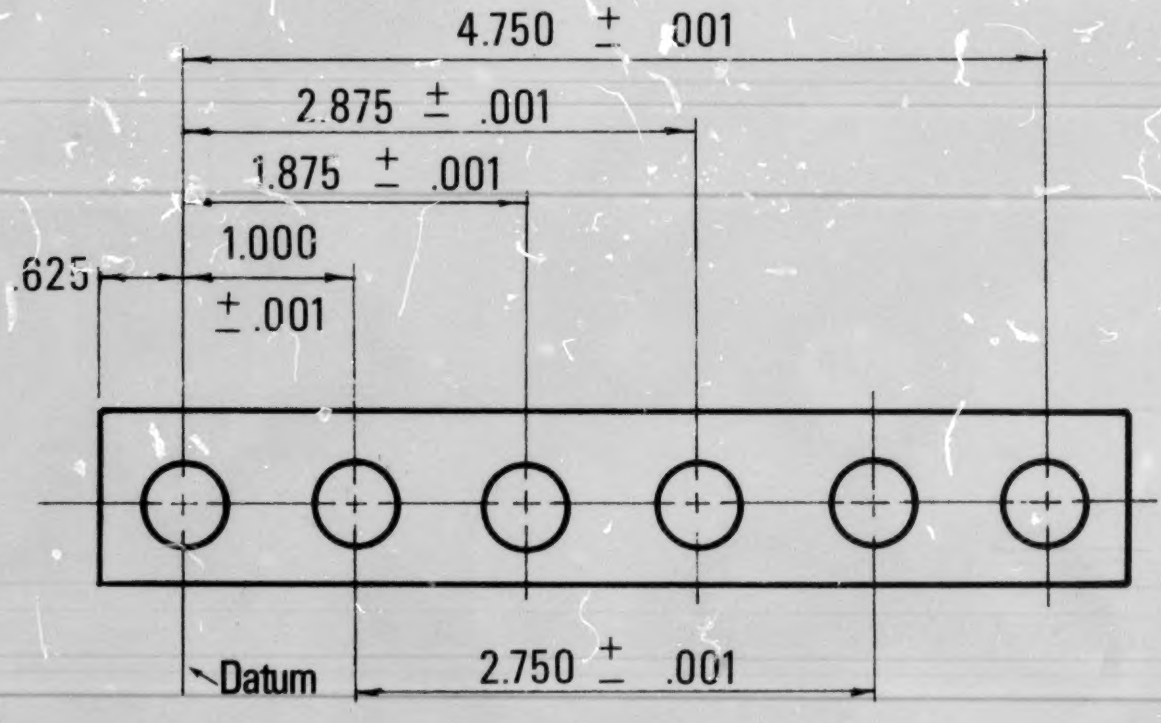

Clearance
Interference

Transition Fit

Types of Dimensioning Systems


Accumulates
.625
1.000
±.001
.8750
±.0003
1.0000
±.0004
.8750
±.0003
1.000
±.001
X
2.750 ± .003
Y

Point-to-Point or Chain Dimensioning


4.750 ± .001
2.875 ± .001
1.875 ± .001
1.000
±.001
.625
Datum
2.750 ± .001

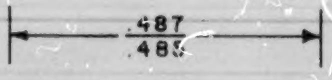
Datum Dimensioning

BASIC TOLERANCING
UNIT V

ASSIGNMENT SHEET #1--INTERPRET DECIMAL TOLERANCE DIMENSIONS

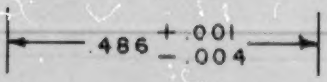
Premise: Limit dimensioning with decimals is used so that parts that require extreme accuracy can be held between very close maximum and minimum limits. Limits are also used when parts can fit very loosely and still function properly. The dimension is called out as liberal as possible leaving the machinist a margin which increases production and lowers cost. Decimal tolerance dimensions can be expressed by any one of the methods in the following example.

Example: 1.



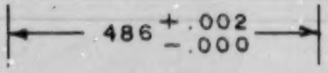
.487 Maximum limit above line
.485 Minimum limit below line
.002 = Tolerance

2.



.487 Maximum limit
.482 Minimum limit

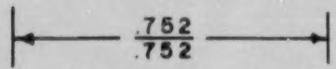
3.



.488 Maximum limit
.486 Minimum limit

4. Shaft basic size 0.750

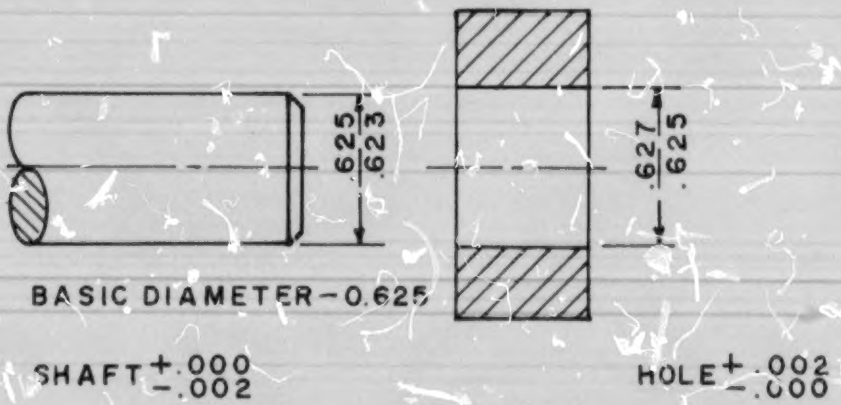
NOTE: Tolerances ± .002 unless otherwise specified



.004 = Tolerance

ASSIGNMENT SHEET #1

5.


.625
.623
.627
.625
BASIC DIAMETER—0.625
SHAFT +.000 −.002
HOLE +.002 −.000

Directions: Determine decimal tolerance dimensions for the following problems.

Problem A: $\frac{.375}{.372}$

Maximum limit = ____________

Minimum limit = ____________

Tolerance = ____________

Problem B: 1.740 ± .002

Maximum limit = ____________

Minimum limit = ____________

Tolerance = ____________

Problem C: .995 $^{+.000}_{-.005}$

Maximum limit = ____________

Minimum limit = ____________

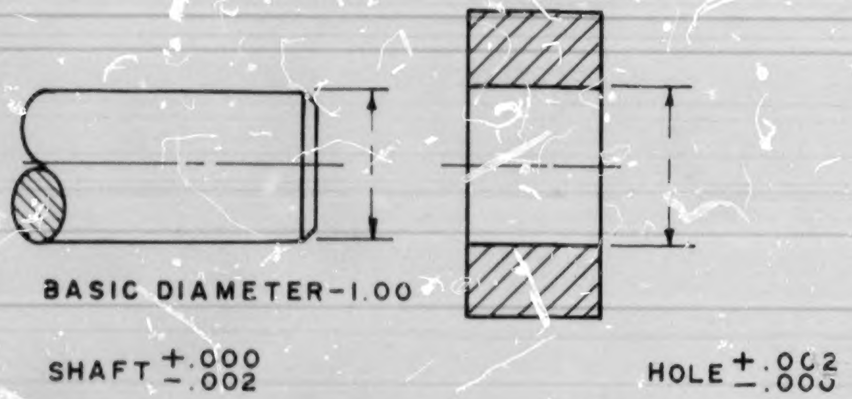
Tolerance = ____________

BASIC TOLERANCING
UNIT V

ASSIGNMENT SHEET #2--CALCULATE AND DIMENSION CLEARANCE FIT TOLERANCES OF MATING PARTS

Directions: Calculate the tolerances and dimension the following problems.

Problem A:


BASIC DIAMETER–1.00
SHAFT +.000 −.002
HOLE +.002 −.000

Tolerance for shaft = ______________

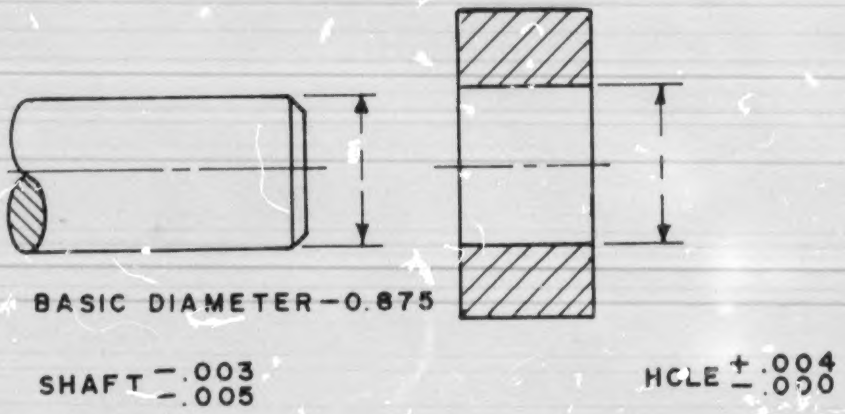
Tolerance for hole = ______________

Allowance = ______________

Maximum clearance = ______________

ASSIGNMENT SHEET #2

Problem B:


BASIC DIAMETER—0.875
SHAFT −.003 −.005
HOLE +.004 −.000

Tolerance for shaft = ____________

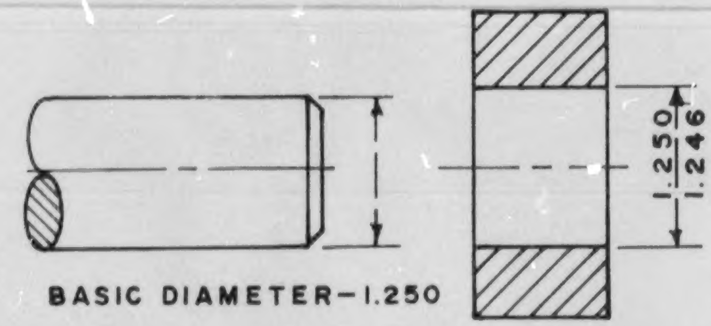
Tolerance for hole = ____________

Allowance = ____________

Maximum clearance = ____________

Directions: Calculate the tolerances and dimension the following word problems.

Problem C: Dimension the shaft to have a tolerance of .004 and a clearance fit with an allowance of .006


1.250
1.246
BASIC DIAMETER—1.250

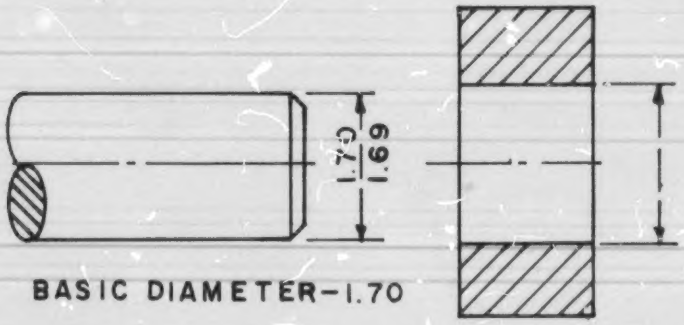
Tolerance for shaft = .004

Tolerance for hole = ____________

Allowance = .006

ASSIGNMENT SHEET #2

Problem D: Dimension the hole to have a tolerance of .010 and a clearance fit with an allowance of .012


1.70
1.69
BASIC DIAMETER–1.70

Tolerance for shaft = ____________

Tolerance for hole = .010

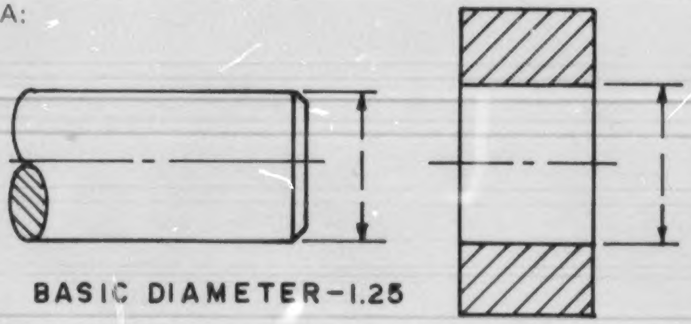
Allowance = .012

BASIC TOLERANCING
UNIT V

ASSIGNMENT SHEET #3--CALCULATE AND DIMENSION INTERFERENCE FIT TOLERANCES OF MATING PARTS

Directions: Calculate the tolerances and dimension the following problems.

Problem A:



BASIC DIAMETER—1.25

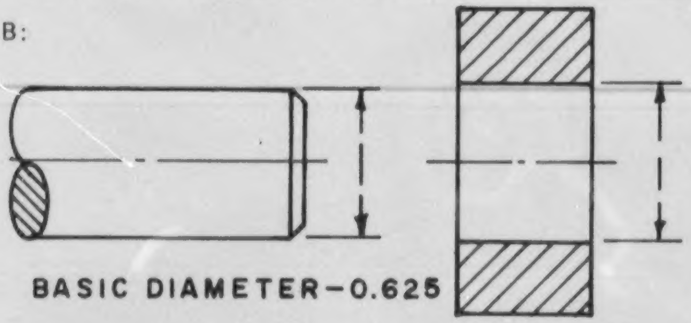
SHAFT $^{+.002}_{-.000}$ **HOLE** $^{+.000}_{-.002}$

Tolerance for shaft = ______________

Tolerance for hole = ______________

Interference = ______________

Problem B:



BASIC DIAMETER—0.625

SHAFT $^{+.001}_{-.000}$ **HOLE** $^{+.000}_{-.003}$

Tolerance for shaft = ______________

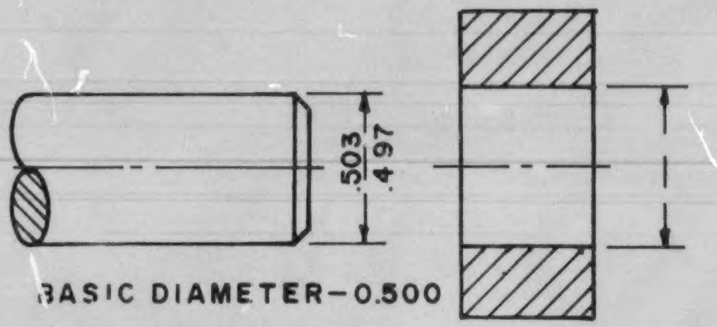
Tolerance for hole = ______________

Interference = ______________

ASSIGNMENT SHEET #3

Directions: Calculate the tolerances and dimension the following word problems.

Problem C: Dimension the hole to have a tolerance of .006 and an interference of .007



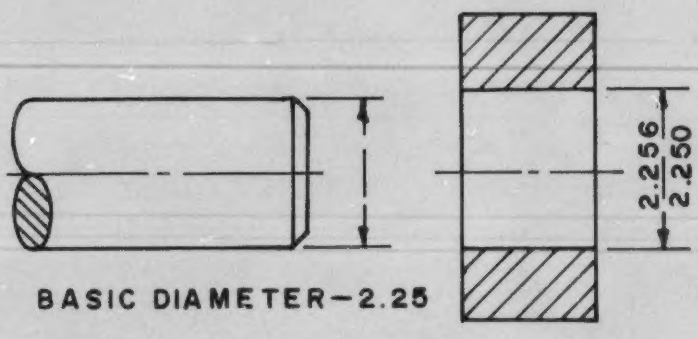
BASIC DIAMETER—0.500

Tolerance for shaft = ____________

Tolerance for hole = .006

Interference = .007

Problem D: Dimension the shaft to have a tolerance of .006 and an interference of .009



BASIC DIAMETER—2.25

Tolerance for shaft = .006

Tolerance for hole = ____________

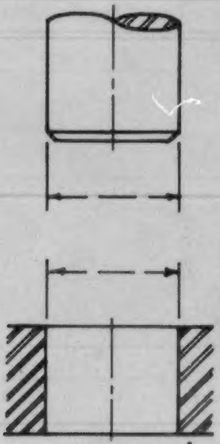
Interference = .009

BASIC TOLERANCING
UNIT V

ASSIGNMENT SHEET #4–CALCULATE AND ASSIGN TOLERANCES TO MATING PARTS USING STANDARD FIT TABLES

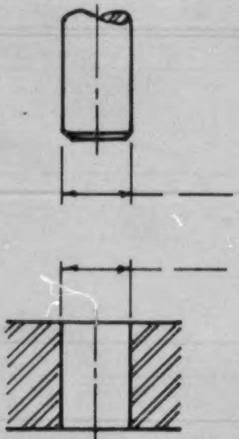
Directions: Calculate and assign tolerances for the problems given below. Standard fit tables are on the next page or use the *Machinery's Handbook*.

Problem A:



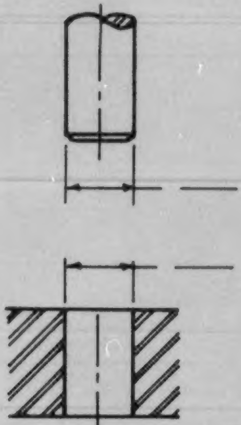
NOMINAL SIZE IS $\frac{1}{2}$ DIA.
TOLERANCE FOR FN2

Problem B:



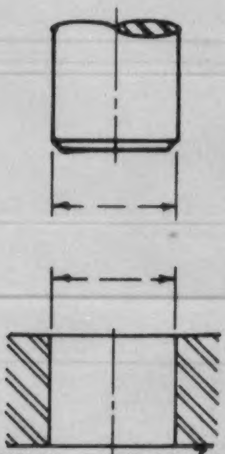
NOMINAL SIZE IS $\frac{3}{4}$ DIA.
TOLERANCE FOR LT2

Problem C:



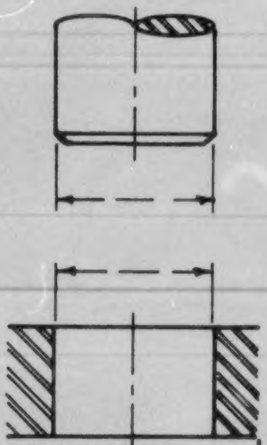
NOMINAL SIZE IS $\frac{5}{8}$ DIA
TOLERANCE FOR LC2

Problem D:



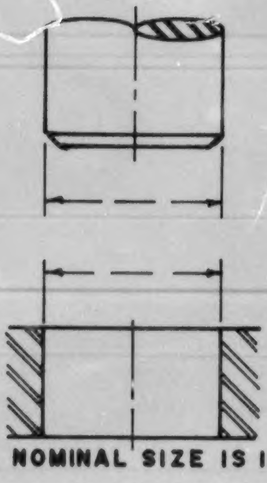
NOMINAL SIZE IS $\frac{7}{8}$ DIA
TOLERANCE FOR RC1

Problem E:



NOMINAL SIZE IS $1\frac{1}{8}$ DIA
TOLERANCE FOR LN2

Problem F:



NOMINAL SIZE IS $1\frac{1}{4}$ DIA
TOLERANCE FOR FN2

ASSIGNMENT SHEET #4

Nominal Size Range Inches Over To	Class RC 2		
	Limits of Clearance	Standard Limits	
		Hole H6	Shaft g5
0 — 0.12	0.1 0.55	+0.25 0	-0.1 -0.3
0.12— 0.24	0.15 0.65	+0.3 0	-0.15 -0.35
0.24— 0.40	0.2 0.85	+0.4 0	-0.2 -0.45
0.40— 0.71	0.25 0.95	+0.4 0	-0.25 -0.55
0.71— 1.19	0.3 1.2	+0.5 0	-0.3 -0.7
[illegible]19— 1.97	0.4 1.4	+0.6 0	-0.4 -0.8

Nominal Size Range Inches Over To	Class LC 2		
	Limits of Clearance	Standard Limits	
		Hole H7	Shaft h6
0 — 0.12	0 0.65	+0.4 -0	+0 -0.25
0.12— 0.24	0 0.8	+0.5 -0	+0 -0.3
0.24— 0.40	0 1.0	+0.6 0	+0 -0.4
0.4[illegible]— 0.71	[illegible] 1.1	+0.7 -0	+0 -0.4
0.71— 1.19	0 1.3	+0.8 0	+0 -0.5
1.19— 1.97	0 1.6	+1.0 0	+0 -0.6

Nominal Size Range Inches Over To	Class LN 2		
	Limits of Interference	Standard Limits	
		Hole H7	Shaft p6
0 — 0.12	0 0.65	+0.4 -0	+0.65 +0.4
0.12— 0.24	0 0.8	+0.5 -0	+0.8 +0.5
0.24— 0.40	0 1.0	+0.6 -0	+1.0 +0.6
0.40— 0.71	0 1.1	+0.7 -0	+1.1 +0.7
0.71— 1.19	0 1.3	+0.8 -0	+1.3 +0.8

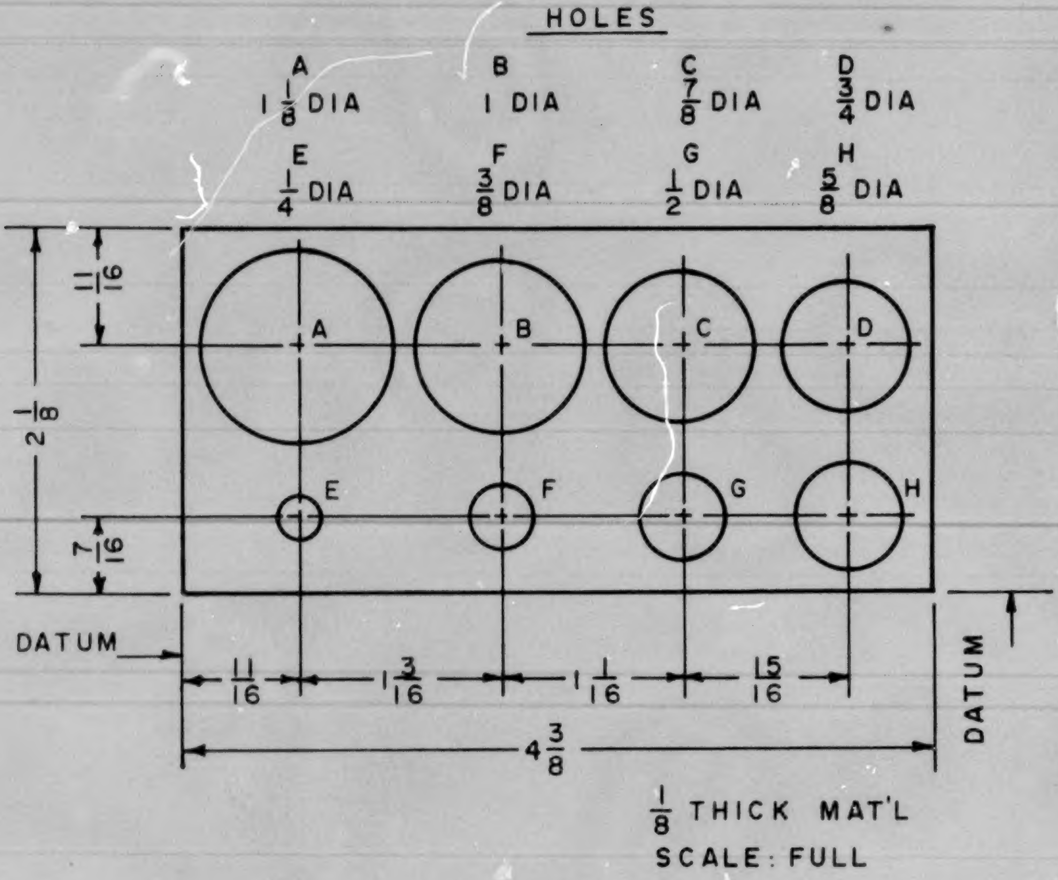
Nominal Size Range Inches Over To	Class FN 1			Class FN 2		
	Limits of Interference	Standard Limits		Limits of Interference	Standard Limits	
		Hole H6	Shaft		Hole H7	Shaft s6
0 —0.12	0.05 0.5	+0.25 -0	+0.5 +0.3	0.2 0.85	+0.4 -0	+0.85 +0.6
0.12—0.24	0.1 0.6	+0.3 -0	+0.6 +0.4	0.2 1.0	+0.5 -0	+1.0 +0.7
0.24—0.40	0.1 0.75	+0.4 -0	+0.75 +0.5	0.4 1.4	+0.6 -0	+1.4 +1.0
0.40—0.56	0.1 0.8	+0.4 -0	+[illegible]8 +0.5	0.5 1.6	+0.7 -0	+1.6 +1.2
0.56—0.71	0.2 0.9	+0.4 -0	+0.9 +0.6	0.5 1.6	+0.7 -0	+1.6 +1.2
0.71—0.95	0.2 1.1	+0.5 -0	+1.1 +0.7	0.6 1.9	+0.8 -0	+1.9 +1.4
0.95—1.19	0.3 1.2	+0.5 -0	+1.2 +0.8	0.6 1.9	+0.8 -0	+1.9 +1.4
1.19—1.58	0.3 1.3	+0.6 -0	+1.3 +0.9	0.8 2.4	+1.0 -0	+2.4 +1.8

Nominal Size Range Inches Over To	Class LT 2		
	Fit	Standard Limits	
		Hole H8	Shaft js7
0 — 0.12	-0.2 +0.8	+0.6 -0	+0.2 -0.2
0.12— 0.24	-0.25 +0.95	+0.7 -0	+0.25 -0.25
0.24— 0.40	-0.3 +1.2	+0.9 -0	+0.3 -0.3
0.40— 0.71	-0.35 +1.35	+1.0 -0	+0.35 -0.35
0.71— 1.19	-0.4 +1.6	+1.2 -0	+0.4 -0.4
1.19— 1.97	-0.5 +2.1	+1.6 -0	+0.5 -0.5

BASIC TOLERANCING
UNIT V

ASSIGNMENT SHEET #5--CONSTRUCT A DRAWING USING DATUM DIMENSIONING

Directions: Construct and dimension the following problem in the space below. Each hole distance from datum is ± .001. Change fractions to decimal dimensions and use datum system.


HOLES
A 1 1/8 DIA
B 1 DIA
C 7/8 DIA
D 3/4 DIA
E 1/4 DIA
F 3/8 DIA
G 1/2 DIA
H 5/8 DIA
11/16
2 1/8
7/16
A
B
C
D
E
F
G
H
DATUM
11/16
1 3/16
1 1/16
15/16
4 3/8
DATUM
1/8 THICK MAT'L
SCALE: FULL

BASIC TOLERANCING
UNIT V

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. Maximum limit = .375
Minimum limit = .372
Tolerance = .003

B. Maximum limit = 1.742
Minimum limit = 1.738
Tolerance = .004

C. Maximum limit = 0.995
Minimum limit = 0.990
Tolerance + .005

Assignment Sheet #2

A.	Tolerance for shaft	= .002	shaft dimensions =	1.000
	Tolerance for hole	= .002		0.998
	Allowance	= .000	hole dimensions =	1.002
	Maximum clearance	= .004		1.000
B.	Tolerance for shaft	= .002	shaft dimensions =	.872
	Tolerance for hole	= .004		.870
	Allowance	= .003	hole dimensions =	.879
	Maximum clearance	= .009		.875
C.	Tolerance for hole	= .004	shaft dimensions =	1.240
				1.236
D.	Tolerance for shaft	= 0.010	hole dimensions =	1.698
				1.688

Assignment Sheet #3

A.	Tolerance for shaft	= .002	hole dimensions =	1.250
	Tolerance for hole	= .002		1.248
	Interference	= .00	shaft dimensions =	1.252
				1.250
B.	Tolerance for shaft	= .001	hole dimensions =	0.624
	Tolerance for hole	= .002		0.622
	Interference	= .001	shaft dimensions =	0.626
				0.625
C.	Tolerance for shaft	= .006	hole dimensions =	.490
				.484

ANSWERS TO ASSIGNMENT SHEETS

D. Tolerance for hole = .006 shaft dimensions = $\frac{2.271}{2.265}$

Assignment Sheet #4

A. Shaft = $\frac{.508}{.505}$
Hole = $\frac{.504}{.500}$

B. Shaft = $\frac{.759}{.746}$
Hole = $\frac{.762}{.750}$

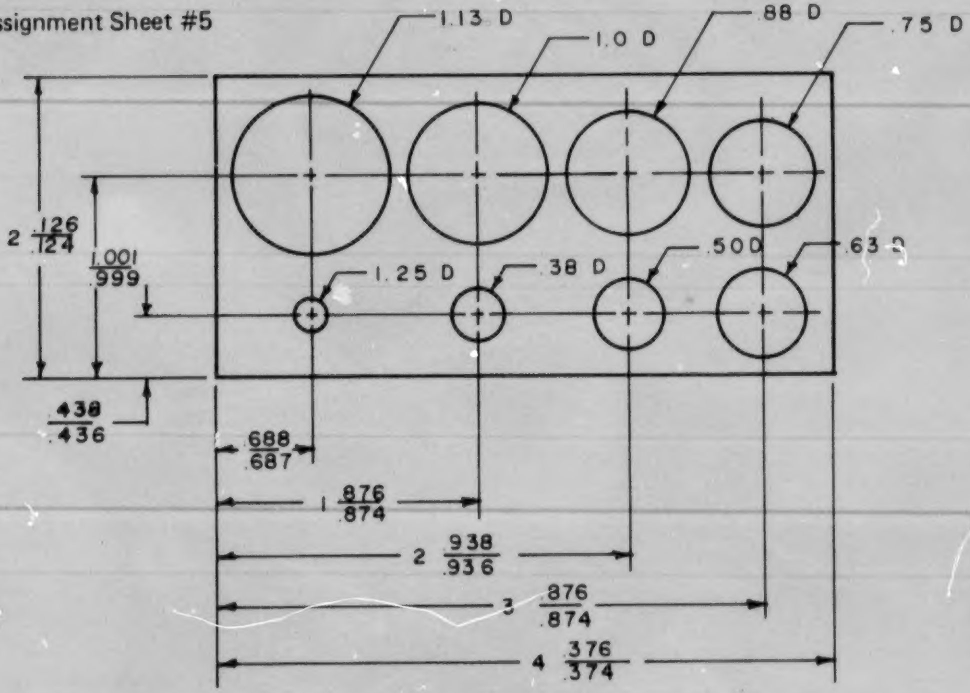
C. Shaft = $\frac{.625}{.621}$
Hole = $\frac{.632}{.625}$

D. Shaft = $\frac{.872}{.8695}$
Hole = $\frac{.879}{.875}$

E. Shaft = $\frac{1.138}{1.133}$
Hole = $\frac{1.133}{1.125}$

F. Shaft = $\frac{1.274}{1.268}$
Hole = $\frac{1.260}{1.250}$

Assignment Sheet #5


1.13 D
1.0 D
.88 D
.75 D
.50 D
.63 D
1.25 D
.38 D
2 .126/.124
1.001/.999
.438/.436
.688/.687
1 .876/.874
2 .938/.936
3 .876/.874
4 .376/.374

BASIC TOLERANCING
UNIT V

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. System designed to control dimensions to allow interchangeability in manufacturing

_____b. The condition that refers to a part made to limit dimensions so that it will fit any part similarly manufactured

_____c. A theoretically exact value used to describe the size, shape, or location of a feature

_____d. A portion of a part, such as a diameter, hole, keyway, or flat surface

_____e. Untoleranced dimensions placed on drawings for the convenience of engineering and manufacturing

_____f. Points, lines, or other geometric shapes assumed to be exact from which the location or geometric form of features of a part may be established

_____g. The classification size given to manufactured products such as pipe or lumber

_____h. The size of a part determined by engineering and design requirements from which the limits of size are determined

_____i. The measured size of an object

_____j. The minimum intentional difference in the dimensions of mating parts to provide for different classes of fits

_____k. Degree of tightness or looseness between mating parts

1. Feature
2. Reference dimension
3. Nominal size
4. Bilateral tolerance
5. Fit
6. Clearance fit
7. Tolerancing
8. Interference fit
9. Actual size
10. Interchangeability
11. Transition fit

______ l. The size of a feature after an allowance for clearance has been applied and tolerances have been assigned

______ m. The extreme permissible dimensions of a part resulting from the application of a tolerance

______ n. The total amount of variation permitted in limit dimension of a part

______ o. The extent to which or the range in which a dimension or size varies

______ p. The variation is in only one direction from the specified dimensions

______ q. The variations permitted are in both directions from the specified dimensions

______ r. Limits of size are determined so that a positive allowance or loose fit occurs between mating parts

______ s. Limits of size are determined so that a negative allowance or tight fit occurs between mating parts

______ t. Limits of size are determined so that the allowance may be either a clearance fit or an interference fit

______ u. Measurements given on a drawing such as size and location

______ v. Method of dimensioning where only the maximum and minimum dimensions are given

______ w. Successive dimensions that extend from one feature to another, rather than each originating at a datum

______ x. Method where features are dimensioned individually from a datum

______ y. The basic size of the shaft is the design size and the allowance is applied to the hole

______ z. The basic size of the hole is the design size and the allowance is applied to the shaft

12. Allowance
13. Dimension
14. Basic dimension
15. Datums
16. Variation
17. Limit dimensioning
18. Chain dimensioning
19. Basic size
20. Datum dimensioning
21. Basic shaft system
22. Design size
23. Basic hole system
24. Tolerance
25. Unilateral tolerance
26. Limits

2. Illustrate the systems of dimensioning tolerances on drawings.

   a. Limits

   b. Plus and minus

   c. Notes

3. List the general types of fits.

   a. ______________________________

   b. ______________________________

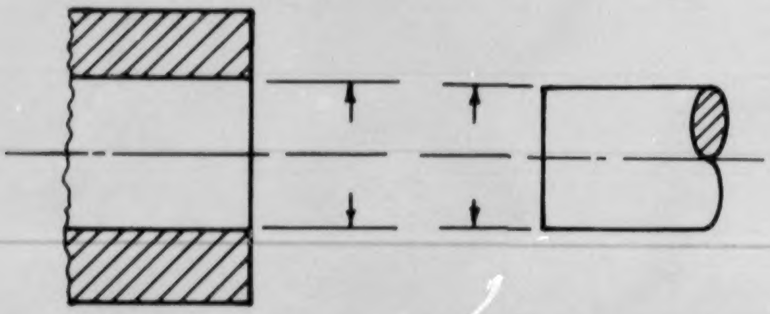
   c. ______________________________

4. Complete the following chart of standard fits.

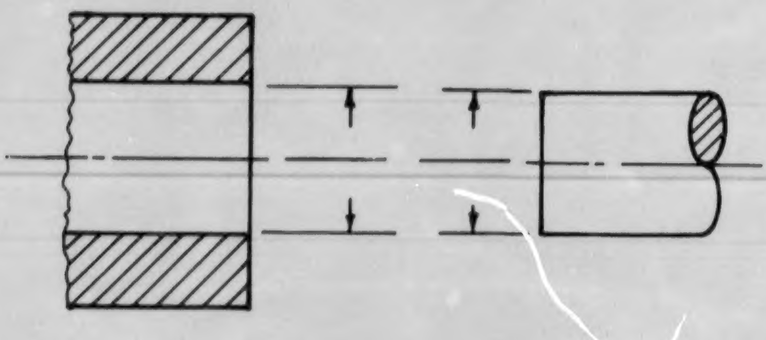
LETTER SYMBOL	CLASS NAME	DESIGNED USE
Running and Sliding Fits		
RC1	Close sliding fit	Parts that will assemble without play
RC2		Greater clearance than RC1
RC3	Precision running fits	Close fits for slow speeds and light shaft pressure
RC4	Close running fit	Accurate machinery with moderate surface speeds
RC5 & RC6	Medium running fit	
RC7	Free running fit	Accuracy is not essential or where large temperature variations exist
RC8 & RC9		Wide commercial tolerances if needed
Locational Fits		
LC1 thru LC11	Locational clearance fits	Parts which can be freely assembled or disassembled
LT1 thru LT6		Medium fit between clearance and interference fit
	Locational interference fits	Provides accuracy of location for parts requiring rigidity and alignment
Force Fits		
FN 1		Parts requiring light assembly pressures
FN2	Medium drive fits	For ordinary steel parts or shrink fits on light sections
FN3	Heavy drive fits	Heavier steel parts or shrink fits in medium sections
FN4 & FN5		Parts which can be highly stressed

5. Determine clearance fit tolerance of mating parts using standard fit tables below for an RC4 fit with a basic diameter of 0.625". Dimension to four decimals. Place answers in the drawing.

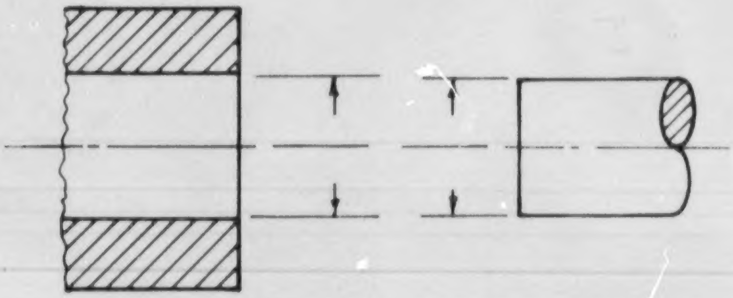
NOMINAL SIZE RANGE INCHES Over To	CLASS FN 2			NOMINAL SIZE RANGE INCHES Over To	CLASS LT 1			CLASS RC 4		
	LIMITS	STANDARD LIMITS			FIT	STANDARD LIMITS		LIMITS	STANDARD LIMITS	
		Hole H7	Shaft S6			Hole H7	Shaft j6		Hole H7	Shaft f7
0.24-0.40	0.1	+0.6	+1.4	0.24-0.40	-0.3	+0.6	+0.3	0.5	+0.6	-0.5
	0.75	- 0	+1.0		+0.7	- 0	-0.1	1.7	0	-1.1
0.40-0.56	0.1	+0.7	+1.6	0.40-0.71	-0.3	+0.7	+0.3	0.6	+0.7	-0.6
	0.8	- 0	+1.2		+0.8	- 0	-0.1	2.0	0	-1.3
0.56-0.71	0.2	+0.7	+1.6	0.71-1.19	-0.3	+0.8	+0.3	0.8	+0.8	-0.8
	0.9	- 0	+1.2		+1.0	- 0	-0.2	2.4	0	-1.6



6. Determine interference fit tolerance of mating parts using standard fit tables accompanying question 5 for an FN 2 fit with a basic diameter of 0.58". Dimension to four decimals. Place answers in the drawing.



7. Determine the limit dimensions of mating parts using standard fit tables accompanying question 5 for an LT 1 fit with a basic diameter of 0.750" Dimension to four decimals. Place answers in the drawing.



8. Distinguish between the types of dimensioning systems by placing an "X" next to the chain dimensioning system.

   ______a. Features are dimensioned from point to point, such as holes, and may accumulate tolerances that exceed specifications

   ______b. Features are dimensioned individually from a datum or zero line and avoid accumulation of tolerances

9. Demonstrate the ability to:

   a. Interpret decimal tolerance dimensions.

   b. Calculate and dimension clearance fit tolerances of mating parts.

   c. Calculate and dimension interference fit tolerances of mating parts.

   d. Calculate and assign tolerances to mating parts using standard fit tables.

   e. Construct a drawing using datum dimensioning.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

BASIC TOLERANCING
UNIT V

ANSWERS TO TEST

1. a. 7
   b. 10
   c. 14
   d. 1
   e. 2
   f. 15
   g. 3
   h. 19
   i. 9
   j. 12
   k. 5
   l. 22
   m. 26
   n. 24
   o. 16
   p. 25
   q. 4
   r. 6
   s. 8
   t. 11
   u. 13
   v. 17
   w. 18
   x. 20
   y. 21
   z. 23

2. Evaluated to the satisfaction of the instructor

3. a. Clearance
   b. Interference
   c. Transition

4.

LETTER SYMBOL	CLASS NAME	DESIGNED USE
Running and Sliding Fits		
RC1	Close sliding fit	Parts that will assemble without play
RC2	Sliding fit	Greater clearance than RC1
RC3	Precision running fits	Close fits for slow speeds and light shaft pressure
RC4	Close running fit	Accurate machinery with moderate surface speeds
RC5 & RC6	Medium running fit	High running speeds or heavy shaft pressures
RC7	Free running fit	Accuracy is not essential or where large temperature variations exist
RC8 & RC9	Loose running fit	Wide commercial tolerances if needed
Locational Fits		
LC1 thru LC11	Locational clearance fits	Parts which can be freely assembled or disassembled
LT1 thru LT6	Locational transition fits	Medium fit between clearance and interference fit
LN1 thru LN3	Locational interference fits	Provides accuracy of location for parts requiring rigidity and alignment
Force Fits		
FN 1	Light drive fits	Parts requiring light assembly pressures
FN2	Medium drive fits	For ordinary steel parts or shrink fits on light sections
FN3	Heavy drive fits	Heavier steel parts or shrink fits in medium sections
FN4 & FN5	Force fits	Parts which can be highly stressed

5. Hole $\frac{.6258}{.6250}$ Shaft $\frac{.6242}{.6234}$

6. Hole $\frac{.5608}{.5600}$ Shaft $\frac{.5616}{.5612}$

7. Hole $\frac{.7500}{.7500}$ Shaft $\frac{.7503}{.7498}$

8. a

9. Evaluated to the satisfaction of the instructor

AUXILIARY VIEWS
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to label points and surfaces, construct auxiliaries of lines, points, planes, and curved surfaces, determine true angle between planes, and determine shortest distance between lines. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to auxiliary views with their correct definitions.
2. Select true statements concerning uses of auxiliary views.
3. Name the views from which a primary auxiliary can be projected.
4. Select true statements concerning projection of measurements in a primary auxiliary view.
5. List the different locations of a reference line.
6. Select true statements concerning projection of measurements in a secondary auxiliary view.
7. Demonstrate the ability to:
    a. Label points and planes of a three view object.
    b. Construct a primary auxiliary of an inclined plane.
    c. Construct a true size auxiliary of a curved surface.
    d. Construct true length of an oblique line.
    e. Determine the true angle and slope of a line.
    f. Determine the true angle between two planes.
    g. Determine visibility of crossing skew lines in space.
    h. Determine the visibility of a line and a plane that cross in space.
    i. Locate piercing point of a line and a plane.

   j. Construct a secondary auxiliary view of an object.
   k. Construct point view of a line.
   l. Determine true angle between two planes in a secondary auxiliary.
   m. Construct a true size auxiliary of an oblique plane.
   n. Determine shortest distance between a point and a line.
   o. Determine shortest distance between two skew lines.

8. Construct various auxiliary views.

AUXILIARY VIEWS
UNIT VI

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information sheet.

VI. Construct a "Glass Box Model" to demonstrate auxiliary projection.

VII. Bring in other blocks or objects.

VIII. Explain the use and need for auxiliary views.

IX. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Primary Auxiliary
    2. TM 2--Primary Auxiliary (Continued)
    3. TM 3--Auxiliary View Projection
    4. TM 4--Need for Auxiliary View
    5. TM 5--Possible Reference Plane Locations
- D. Assignment sheets
    1. Assignment Sheet #1--Label Points and Planes of a Three View Object
    2. Assignment Sheet #2--Construct a Primary Auxiliary of an Inclined Plane
    3. Assignment Sheet #3--Construct a True Size Auxiliary of a Curved Surface
    4. Assignment Sheet #4--Construct True Length of an Oblique Line

5. Assignment Sheet #5--Determine the True Angle and Slope of a Line
6. Assignment Sheet #6--Determine the True Angle Between Two Planes
7. Assignment Sheet #7--Determine Visibility of Crossing Skew Lines in Space
8. Assignment Sheet #8--Determine the Visibility of a Line and a Plane that Cross in Space
9. Assignment Sheet #9--Locate Piercing Point of a Line and a Plane
10. Assignment Sheet #10--Construct a Secondary Auxiliary View of an Object
11. Assignment Sheet #11--Construct Point View of a Line
12. Assignment Sheet #12--Determine True Angle Between Two Planes in a Secondary Auxiliary
13. Assignment Sheet #13--Construct a True Size Auxiliary of an Oblique Plane
14. Assignment Sheet #14--Determine Shortest Distance Between a Point and a Line
15. Assignment Sheet #15--Determine Shortest Distance Between Two Skew Lines

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Giesecke, Frederick E., et al. *Technical Drawing.* New York: Macmillan Publishing Co., Inc., 1980.

B. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

C. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

D. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing.* New York: Macmillan Publishing Co., Inc., 1968.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

AUXILIARY VIEWS
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Edge view--A line representing the inclined plane

B. Auxiliary view--A view or surface that is not perpendicular or right angle to the plane of projection

C. Line of sight--Direction from which an object is being viewed

D. Partial auxiliary--Shows only the true size and detail of the inclined plane

(NOTE: Hidden lines are omitted.)

E. Inclined plane--A plane that is foreshortened in two principal viewing planes and edge view in one other principal viewing plane

F. Foreshortened--To appear shorter to the eye than it actually is

G. Primary auxiliary view--A first projection of an inclined plane from one of the principal views

H. Secondary auxiliary view--Oblique plane or line projected from a primary auxiliary view and one of the principal views

I. True size--A surface that is shown in its actual size

(NOTE: This is based upon the scale used.)

J. Oblique plane--A plane that is foreshortened in all three principal viewing planes

K. Transfer--Take from one point or view and put in another view

L. True length line--A line that appears in its actual length

M. Perpendicular line--A line at 90° to a given plane of projection

N. Reference line A common line on back side, center, front side, or between views from which depth measurements are taken

O. Fold line--A theoretical line between two views where viewing planes fold

P. Symmetrical--Has same shape and size on opposite sides of a center line

Q. Grade--The degree of inclination of a slope

R. Slope--The angle a line makes with the horizontal plane

INFORMATION SHEET

S. True angle--An angle formed by two intersecting planes

(NOTE: This is often referred to as a dihedral angle.)

T. Skew lines--Nonintersecting lines, not parallel to each other or to the principal views

II. Uses of auxiliary views

A. Determine clearance distances and angles between manufactured parts

B. Describe inclined surfaces of manufactured parts

C. Determine percent of slope on pipelines, sewer lines, and grades on highway construction

D. Determine "dip" or slope angle of geological formations

E. Determine true length of structural members

III. Views from which a primary auxiliary can be projected--All six views

IV. Projection of measurements in a primary auxiliary view (Transparencies 1, 2, 3, and 4)

A. Depth and height measurements are transferred with a scale or dividers in their true length from one of five views

B. Measurements cannot be made from view with edge view

C. Length measurements are projected in their true length perpendicular from edge view to primary auxiliary

V. Different locations of a reference line (Transparency 5)

A. Back edge of view

B. Center line

C. Front edge of view

D. Between views

(NOTE: These are referred to as fold lines.)

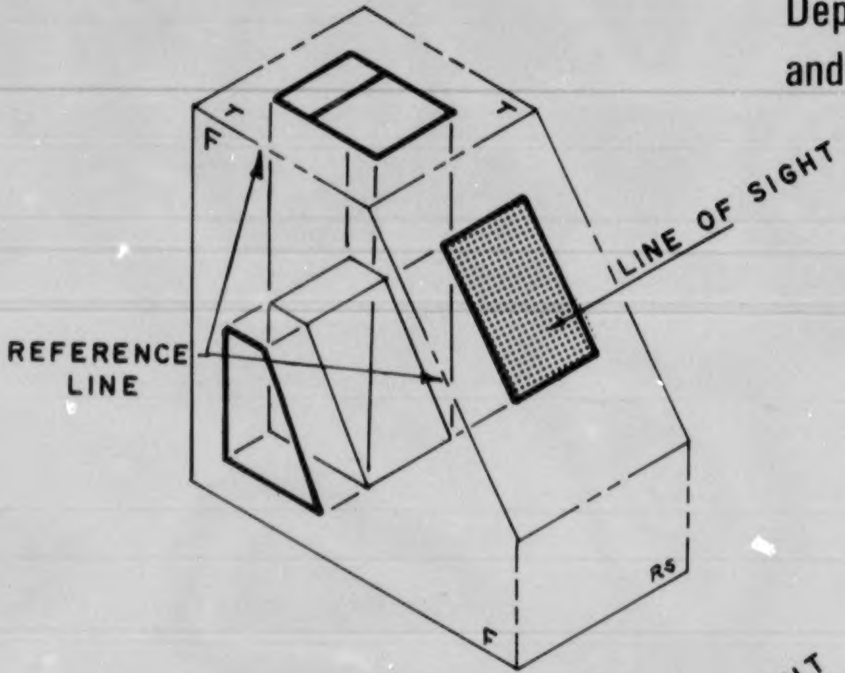
VI. Projection of measurements in a secondary auxiliary view

A. Depth measurements are transferred from the edge view of one of the principal views

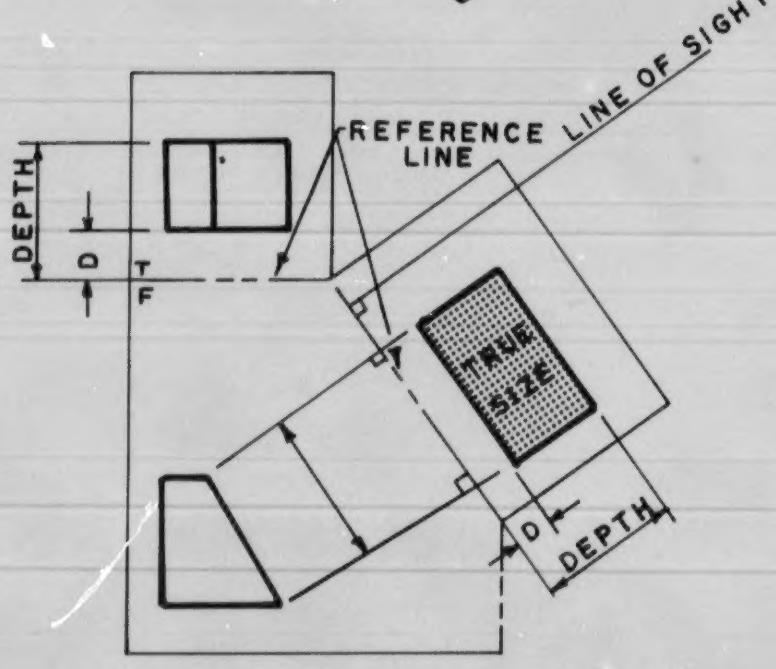
B. Length measurements are projected from primary auxiliary view

Primary Auxiliary

Depth Equal in Top and Auxiliary Views

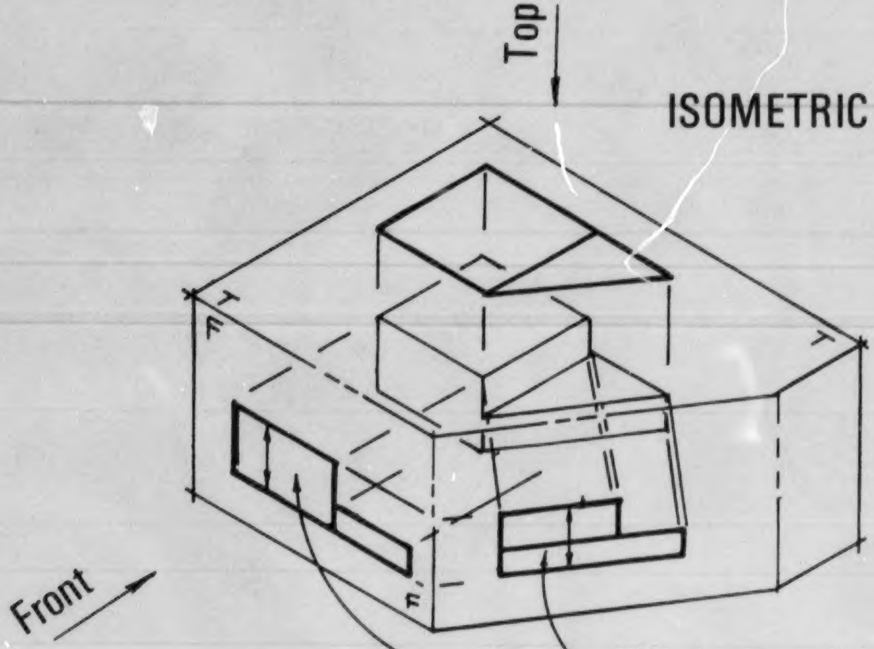

T
T
F
REFERENCE LINE
LINE OF SIGHT
RS
F

ISOMETRIC VIEWS


DEPTH
D
T
F
REFERENCE LINE
LINE OF SIGHT
TRUE SIZE
D
DEPTH

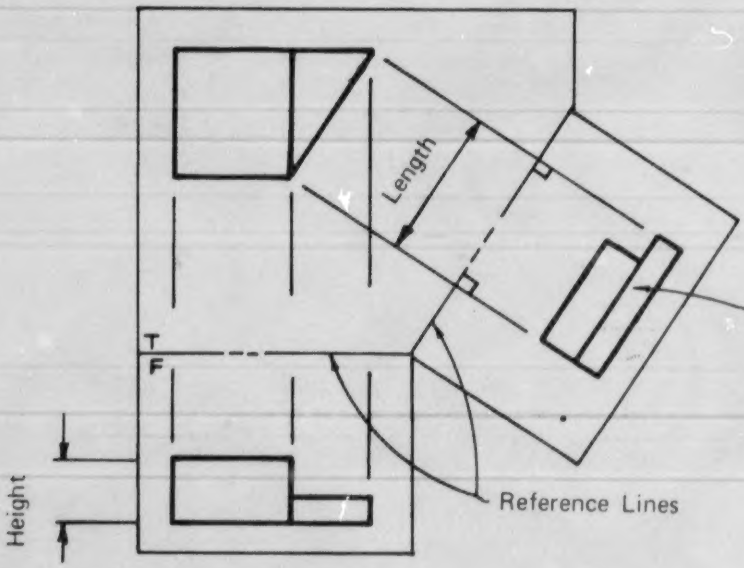
ORTHOGRAPHIC VIEWS

Primary Auxiliary (Continued)


Top
T
F
T
F
Front

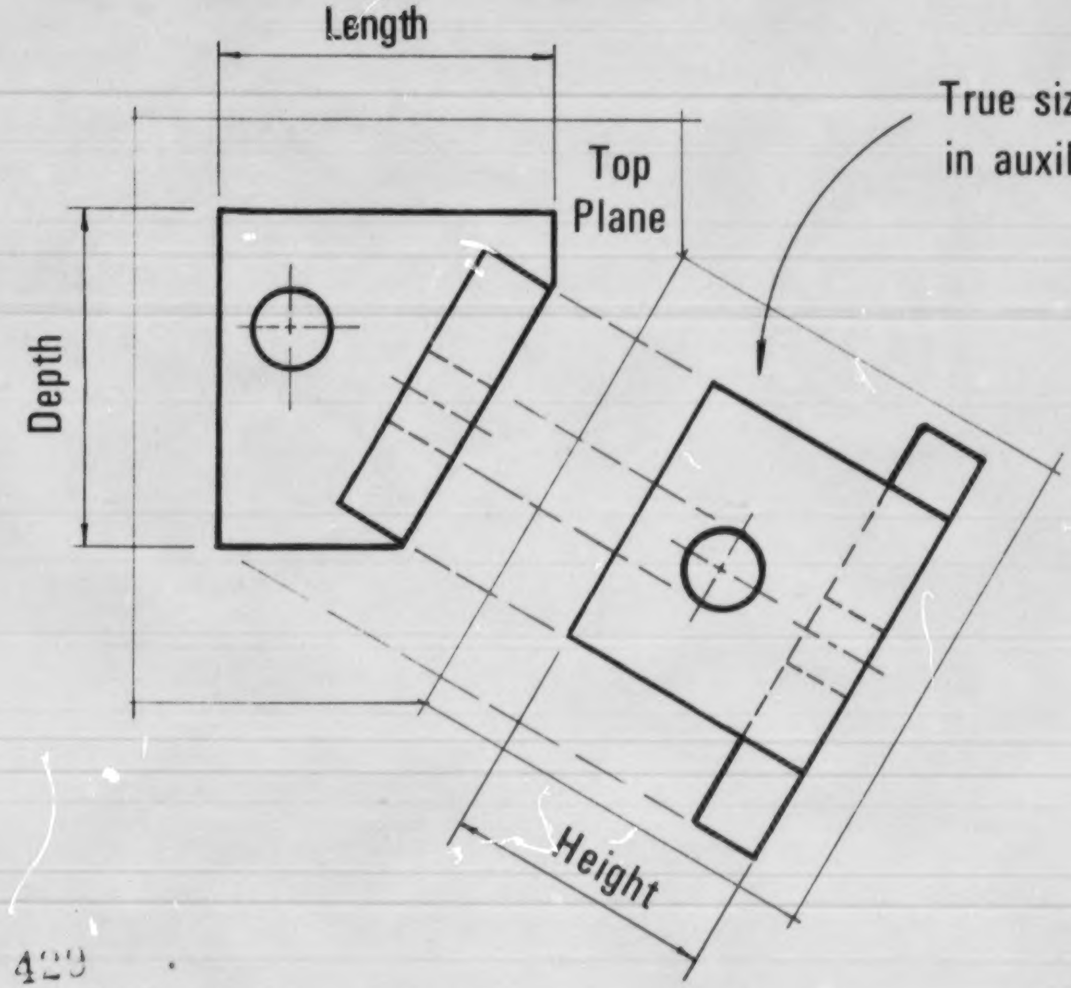
ISOMETRIC VIEWS

Height Equal in Front and Auxiliary View


Length
T
F
Height
Reference Lines

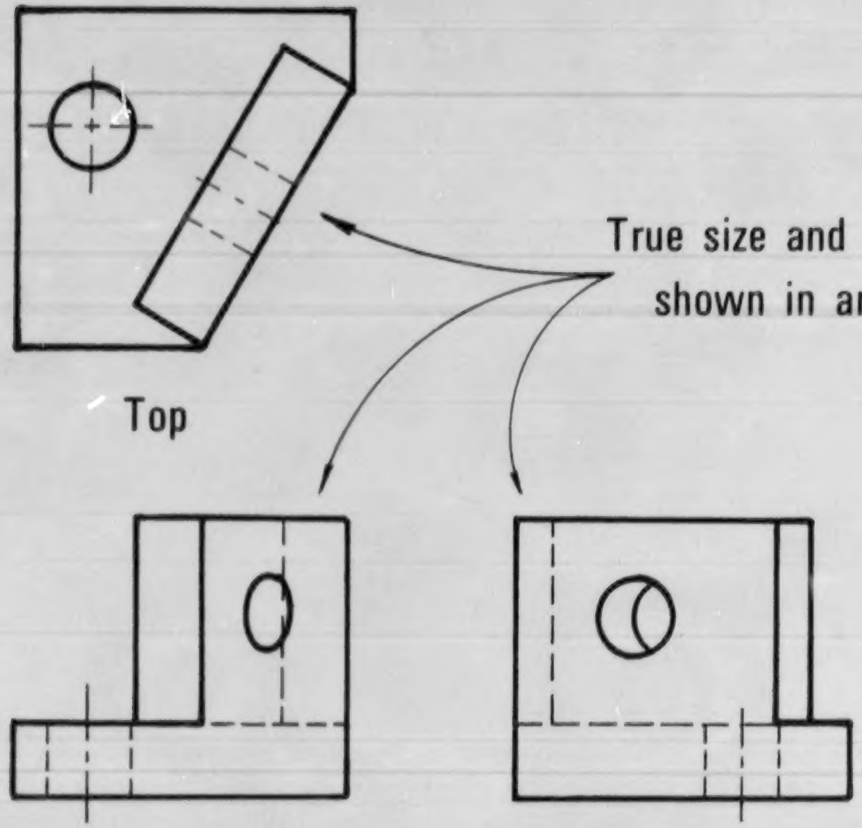
True size of sloped surface.

Auxiliary View Projection


Length
Top Plane
Depth
Height

True size of sloped surface in auxiliary plane.

Need for Auxiliary View



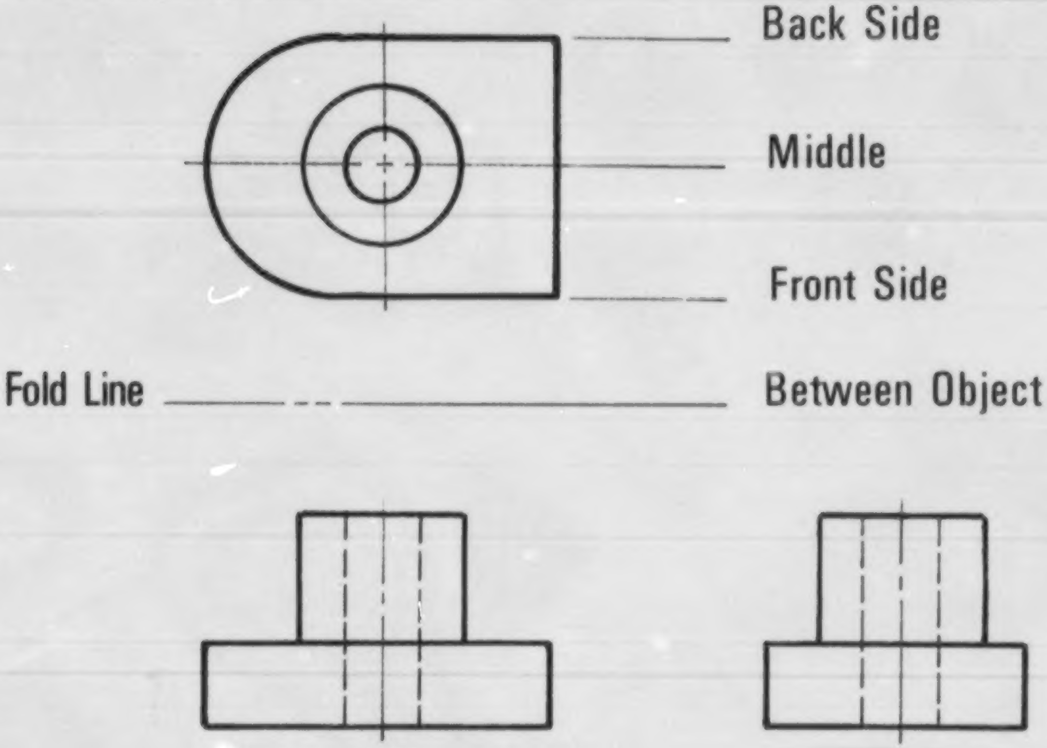
True size and shape of surface not shown in any regular view.

Top

Front

Right Side

Possible Reference Plane Locations



Back Side

Middle

Front Side

Fold Line

Between Object

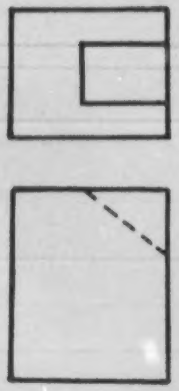
AUXILIARY VIEWS
UNIT VI

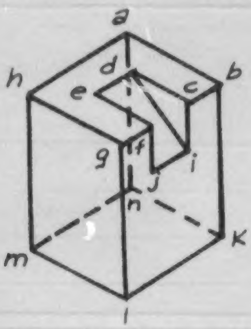
ASSIGNMENT SHEET #1--LABEL POINTS AND PLANES OF A THREE VIEW OBJECT

Premise: When two planes meet, they form a line; when two lines meet, they form a point. An object is made of lines, points, and planes. In drawing auxiliary views of an object, it becomes necessary to label these lines, points, and planes with letters or numbers to be absolutely sure that the auxiliary views are formed correctly. Labeling points is not used in all of auxiliary view drawing, but it is beneficial on hard-to-visualize objects. Points and planes of a three view object can be labeled by using the procedure in the following example.

Example:

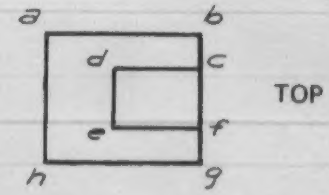
1. Use given two views of an object with a pictorial showing location of all points



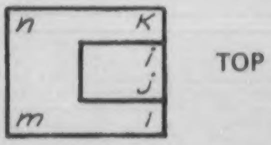


2. Start with top view and label all points that make up the corners of the top plane

   (NOTE: Use lower case letters; if two corners are on the same point, put the letter outside the object to indicate point closest to observer.)



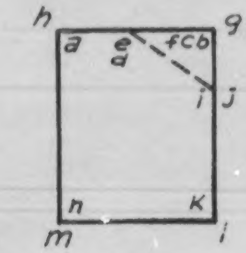
3. Label points that are away from observer by putting their point callout letters inside the object



ASSIGNMENT SHEET #1

4. Use same procedure to locate point letter callouts in front view

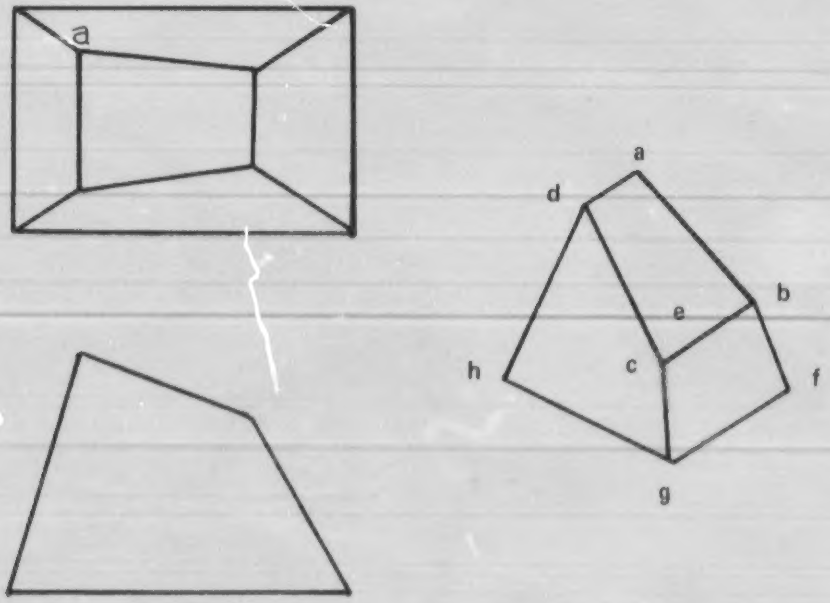
   (NOTE: Points closest go outside the object; those behind go inside the object.)



FRONT

Directions: Label points of the object below using lower case letters. Start at point a.

Problem:



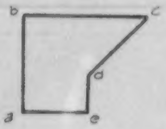
AUXILIARY VIEWS
UNIT VI

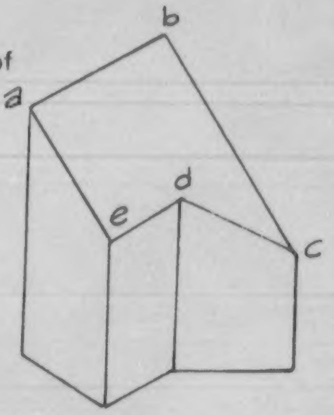
ASSIGNMENT SHEET #2--CONSTRUCT A PRIMARY AUXILIARY OF AN INCLINED PLANE

Premise: Many objects have a plane that is inclined; if this plane needs to be dimensioned, it will be necessary to draw it true size. A primary auxiliary of an inclined plane can be constructed by using the procedure in the following example.

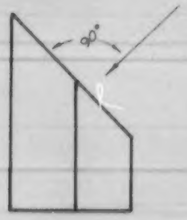
Example:

1. Use given top and front view; draw auxiliary view of plane abcde



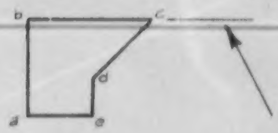


2. Determine line of sight perpendicular to edge view of plane abcde to be drawn to true size



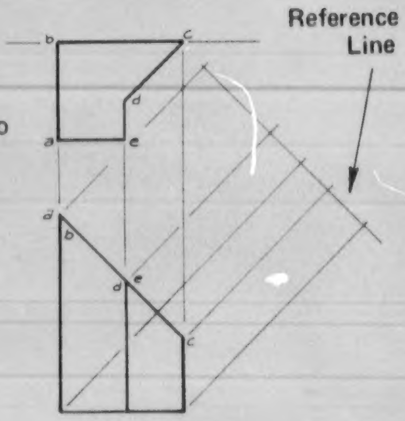
3. Locate reference line in the top view in either of the following places: back, middle, front, or between views

   (NOTE: The back of the top view was used for this example.)



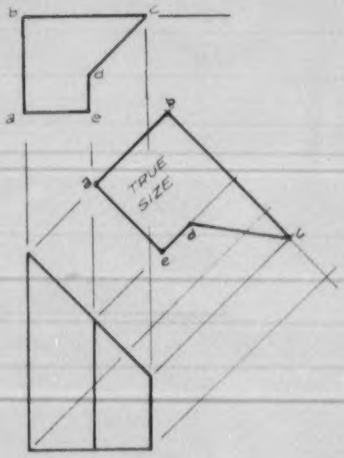
ASSIGNMENT SHEET #2

4. Locate reference line in auxiliary view perpendicular to line of sight at an adequate distance from edge of front view


Reference Line
b
c
d
a
e
a
b
d
e
c

5. Draw light projection lines from points of plane to be drawn to true size

6. Locate points on or in relation to reference plane by transferring measurements from top view with dividers

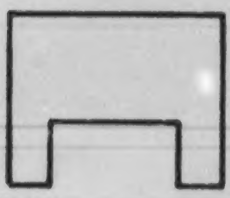

b
c
d
a
e
b
a
TRUE SIZE
d
c
e

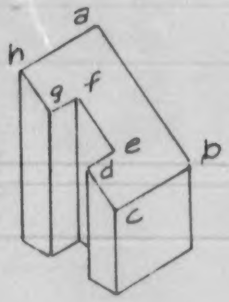
7. Connect points in auxiliary view that appear to be connected in top view; darken lines

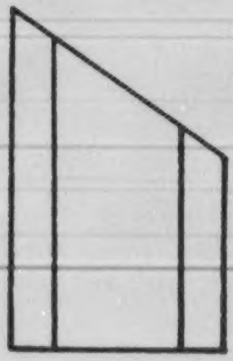
ASSIGNMENT SHEET #2

Directions: Label points and draw an auxiliary view of the inclined planes. Leave all construction lines.

Problem A:

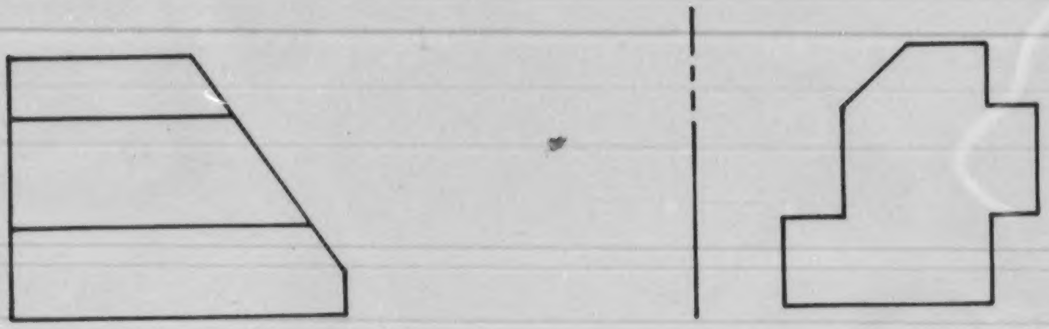




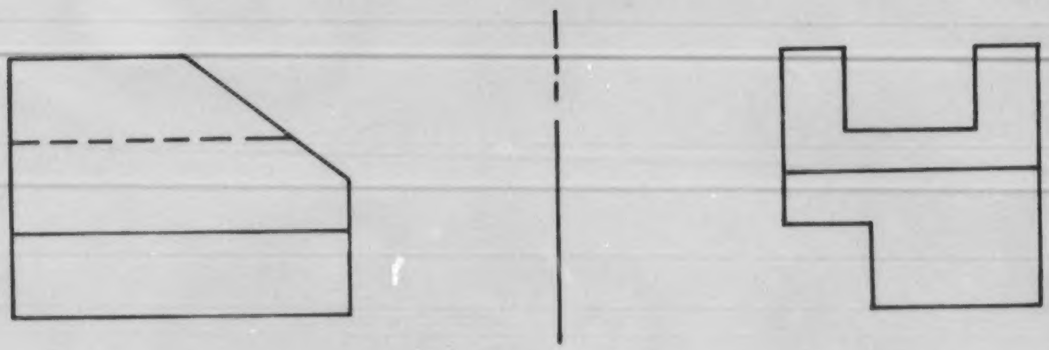


ASSIGNMENT SHEET #2

Problem B:



Problem C:



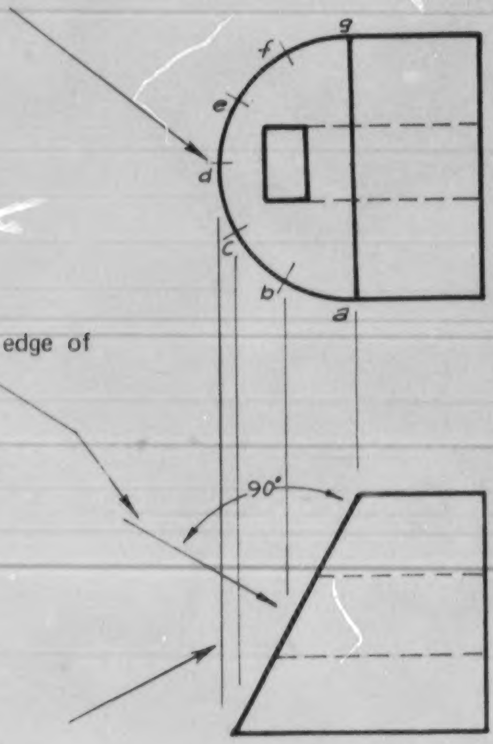
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #3--CONSTRUCT A TRUE SIZE AUXILIARY OF A CURVED SURFACE

Premise: A curved surface such as a circle is divided up into a series of points, and points are used to plot the true size of the curved surface. A true size auxiliary of a curved surface can be constructed by using the procedure in the following example.

Example:

1. Given an object that has a surface in the front view that is cut at an angle, divide the top view up into a series of points and number or letter each point
2. Assume a line of sight perpendicular to the edge of the sloped surface

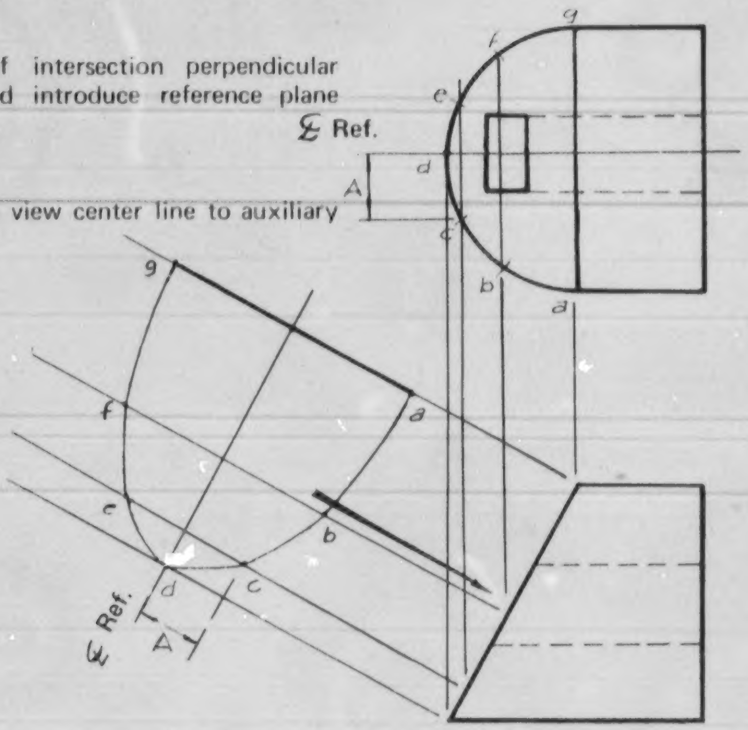


3. Project points of circle in top view to edge of surface in front view

ASSIGNMENT SHEET #3

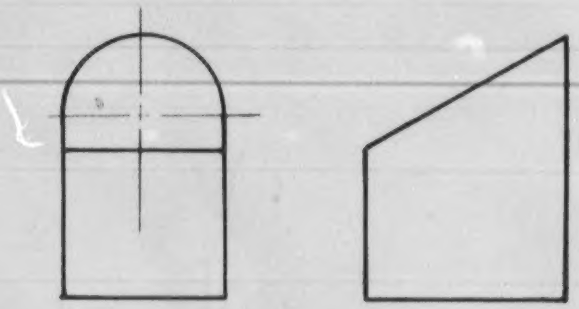
4. Project these points of intersection perpendicular to the surface edge and introduce reference plane center line

5. Transfer points from top view center line to auxiliary view center line



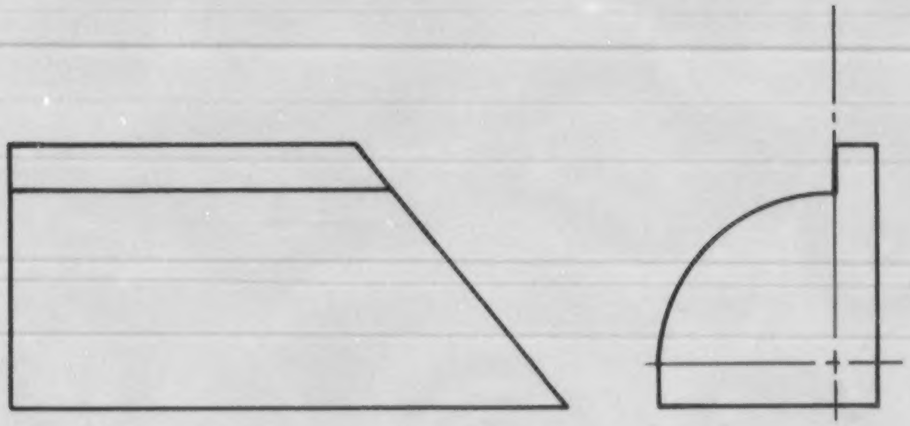
Directions: Construct a true size auxiliary view of the following inclined surfaces.

Problem A:

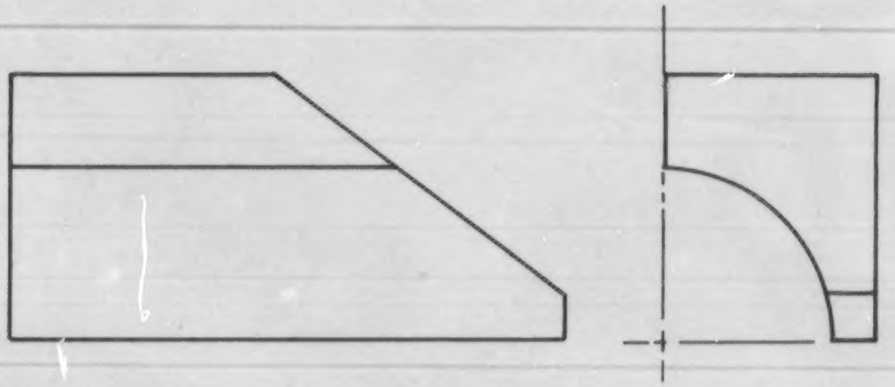


ASSIGNMENT SHEET #3

Problem B:



Problem C:



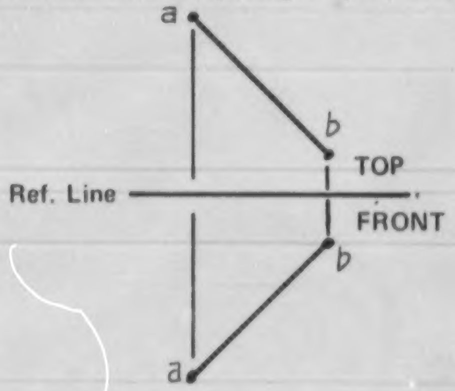
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #4--CONSTRUCT TRUE LENGTH OF AN OBLIQUE LINE

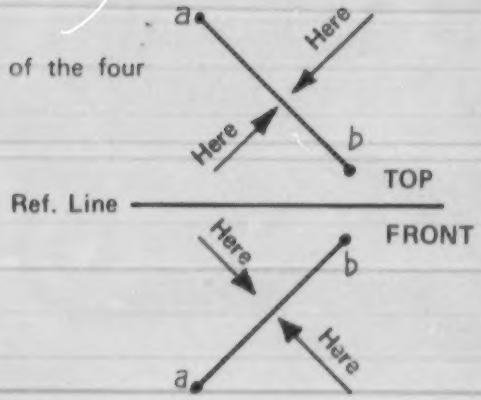
Premise: When a line is oblique to any principal views, an auxiliary view is required to find the true length. True length of an oblique line can be constructed by using the procedure in the following example.

Example:

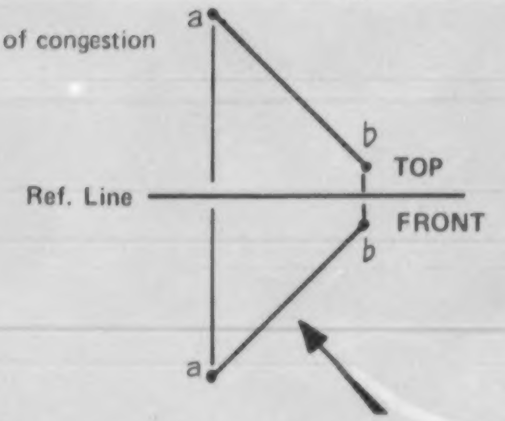
1. Use given two views of a skewed line a-b


a
b
TOP
Ref. Line
FRONT
b
a

2. Assume 90° line of sight from any one of the four directions shown

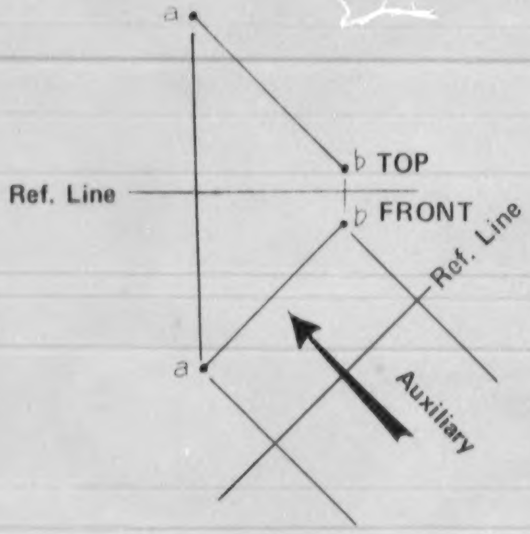

a
Here
Here
b
TOP
Ref. Line
FRONT
Here
b
Here
a

3. Select a line of sight with least amount of congestion and most drawing space

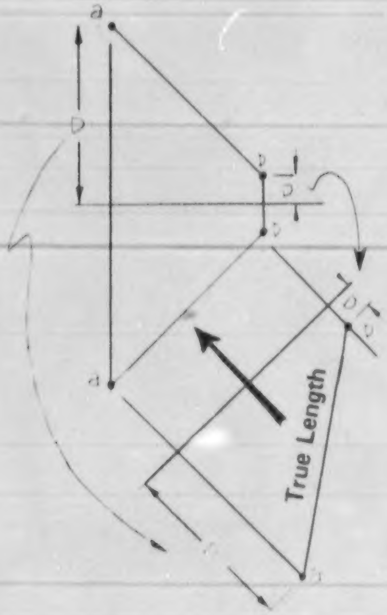

a
b
TOP
Ref. Line
FRONT
b
a

ASSIGNMENT SHEET #4

4. Assume reference line at a convenient distance perpendicular to line of sight; project points a-b through reference plane


a
b TOP
Ref. Line
b FRONT
Ref. Line
a
Auxiliary

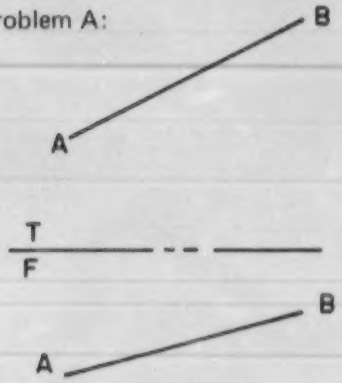
5. Transfer points a and b from top view and connect points to form true length line


a
D
b
D
b
a
D
b
True Length
D
b

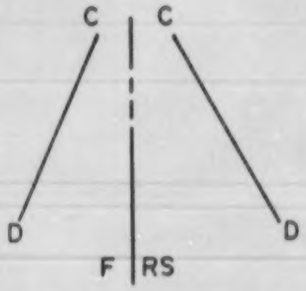
ASSIGNMENT SHEET #4

Directions: Construct true length of the lines given below. Label line TL.

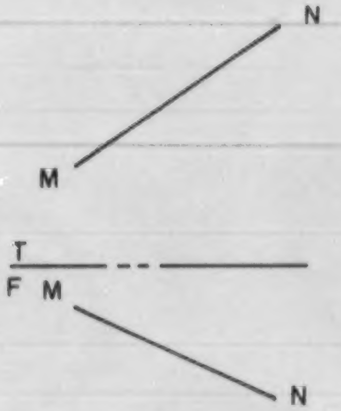
Problem A:



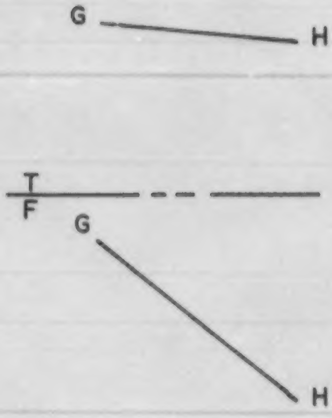
Problem B:



Problem C:



Problem D:



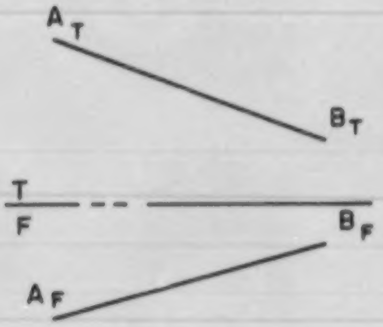
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #5--DETERMINE THE TRUE ANGLE AND SLOPE OF A LINE

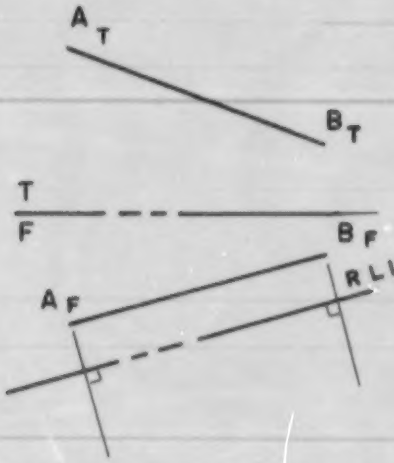
Premise: The slope of a line is the angle the line makes with the top view. The slope may be expressed in percent or degrees of grade. When the line of slope is oblique to principal views, a primary auxiliary is needed to find true length of line. The slope of pipeline systems must be specified on drawings for gravity flow. The true angle and slope of a line can be determined by using the procedure in the following example.

Example:

1. Use given top and front view of slope of line A-B

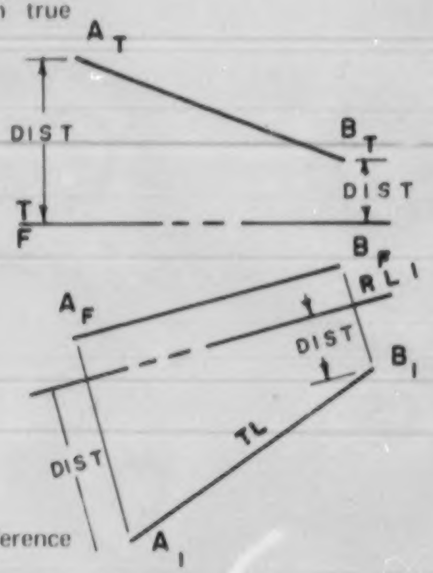


2. Construct reference line RL1 parallel to line A_F-B_F



ASSIGNMENT SHEET #5

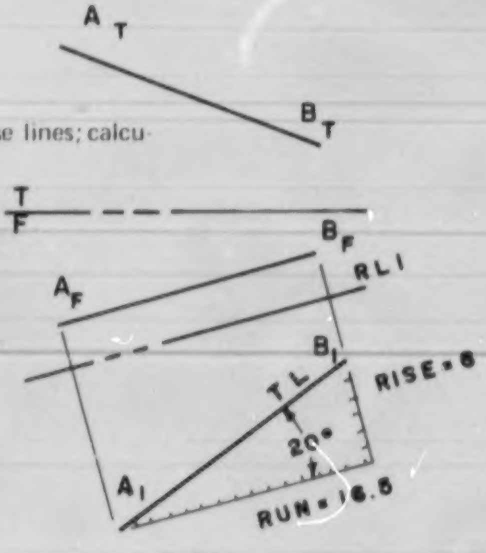
3. Project end points perpendicular to line A_F, B_F and transfer distances from top view to establish true length line


A_T
DIST
B_T
DIST
T
F
B_F
RL 1
A_F
DIST
B_1
TL
DIST
A_1

4. Construct a line parallel and perpendicular to reference line to establish run and rise to slope

5. Use scale to mark divisions on run and rise lines; calculate percent slope

6. Measure angle with protractor


A_T
B_T
T
F
B_F
RL 1
A_F
B_1
TL
RISE = 6
20°
A_1
RUN = 16.5

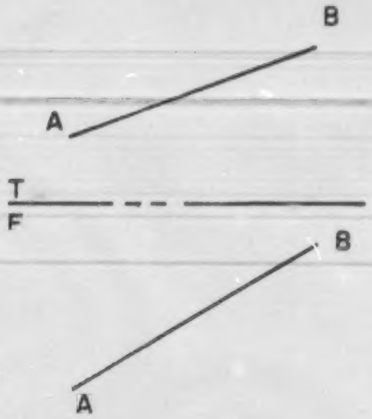
$$\text{SLOPE} = \frac{\text{RISE}}{\text{RUN}}$$

$$\text{SLOPE} = \frac{6}{16.5} = 36\ \%$$

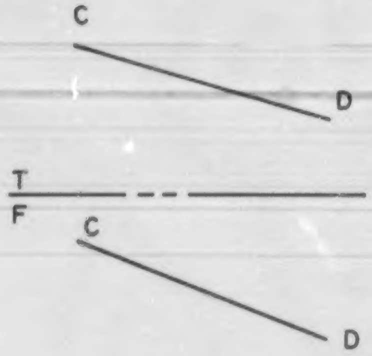
Directions: Construct the length of lines in the following problems. Calculate percent slope and measure angle.

ASSIGNMENT SHEET #5

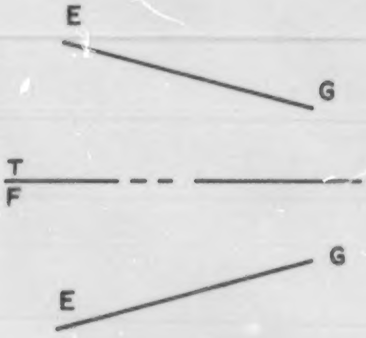
Problem A:



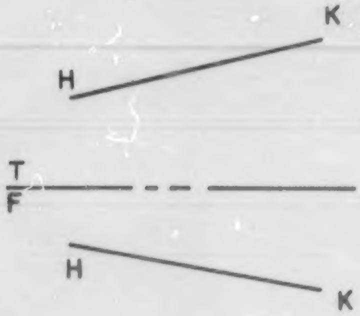
Problem B:



Problem C:



Problem D:



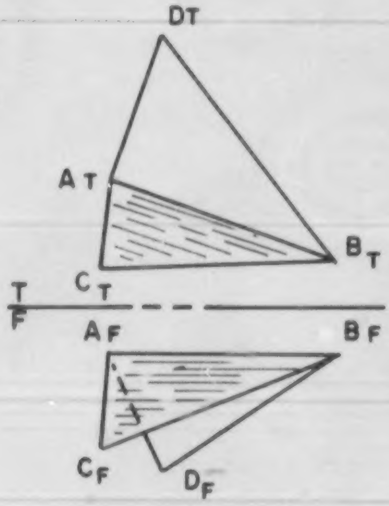
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #6--DETERMINE THE TRUE ANGLE BETWEEN TWO PLANES

Premise: In the design and manufacture of the parts, it is sometimes necessary to determine the angle between two planes. This angle can be determined when the line of intersection is parallel to one of the principal views. The true angle between two planes can be determined by using the procedure in the following example.

Example:

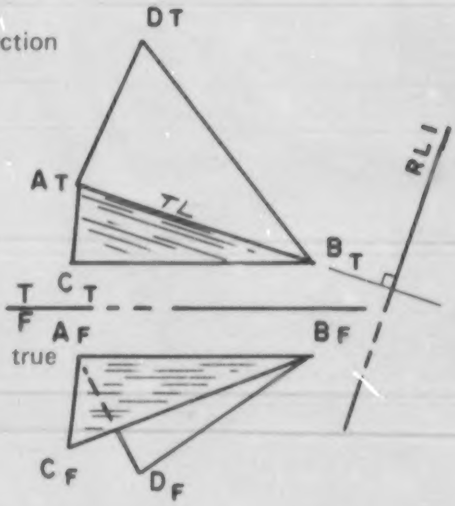
1. Use given top and front views of the two planes



2. Line of intersection at A_T B_T is viewed in its true length in top view

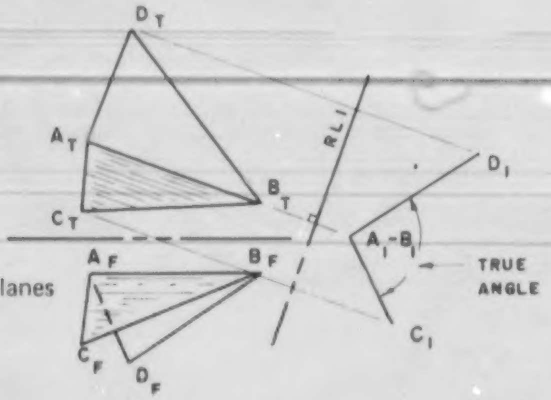
   (NOTE: For this procedure that line of intersection must be parallel to one of the principal planes.)

3. Construct reference line RL1 perpendicular to true length line



ASSIGNMENT SHEET #6

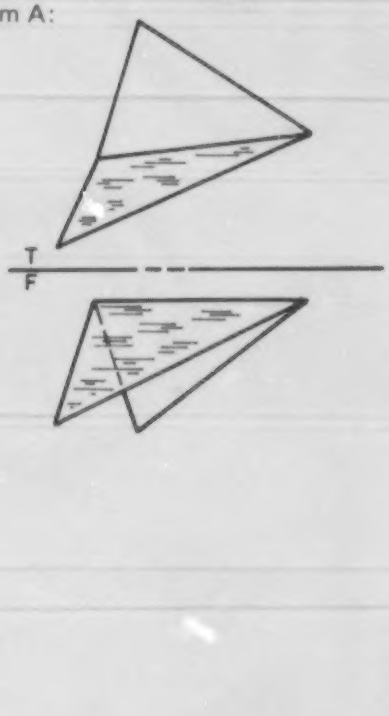
4. Project points from top view to primary auxiliary perpendicular to reference line; transfer distances from front view to primary auxiliary to establish edge view of planes



5. Measure true angle between the two planes

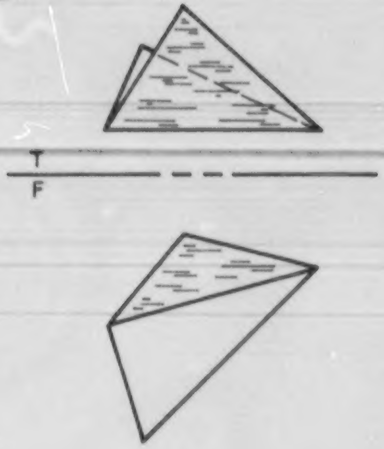
Directions: Determine the true angle between two planes in the following problems. Measure angle with protractor. Label corners of planes. Leave construction lines.

Problem A:



ASSIGNMENT SHEET #6

Problem B:



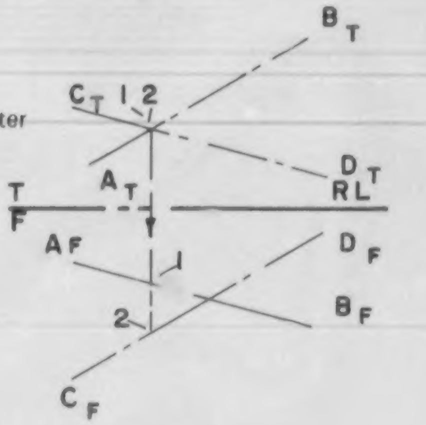
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #7--DETERMINE VISIBILITY OF CROSSING SKEW LINES IN SPACE

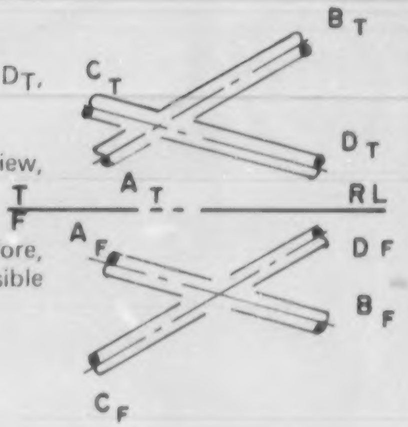
Premise: In the example of two nonintersecting pipes shown below, the visibility of the pipe nearest to the viewer cannot be determined. The procedure in the following example can be used to determine which pipe lies in front of the other.

Example:

1. Use given two views of crossing pipes with center lines labeled



2. Determine visibility of line in top view
   - a. Label the crossing of lines A_T, B_T, and C_T, D_T, as 1, 2
   - b. Project the crossing point to the front view, establishing points 1, 2
   - c. Point 1 is closer to reference line; therefore, line A_T, B_T is nearer in top view and is visible

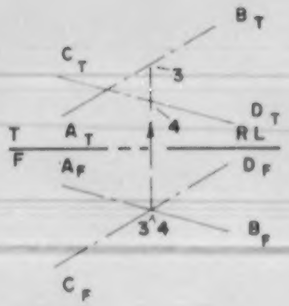


ASSIGNMENT SHEET #7

3. Determine the visible line in front view

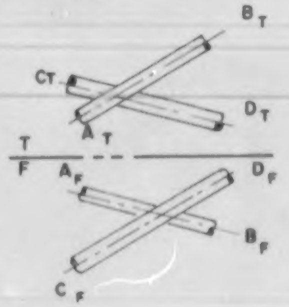
   a. Label the crossing of lines A_F, B_F, and C_F, D_F as 3, 4

   b. Project the crossing point to the top view, establishing points 3, 4



B_T
C_T
3
D_T
T
A_T
4
RL
F
A_F
D_F
3 4
B_F
C_F

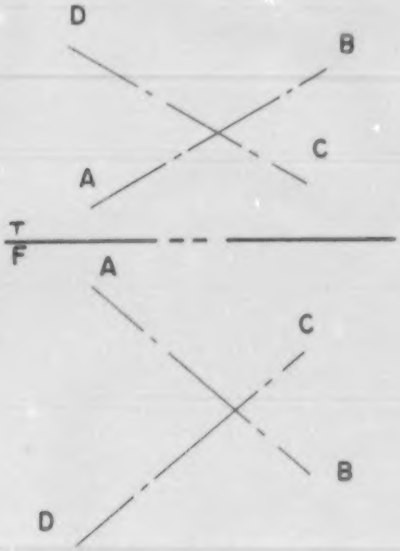
   c. Point 4 is closer to reference line; therefore, line A_F, B_F is nearer in front view and is visible



B_T
CT
D_T
A_T
T
F
A_F
D_F
B_F
C_F

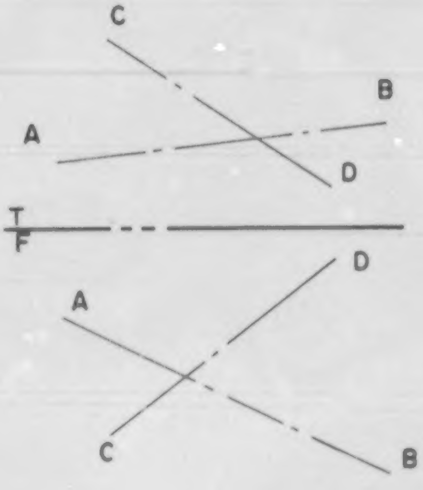
Directions: Determine which pipe is closer to the viewer in the following views. Complete the shape of pipes and leave projection lines.

Problem A:



D
B
C
A
T
F
A
C
B
D

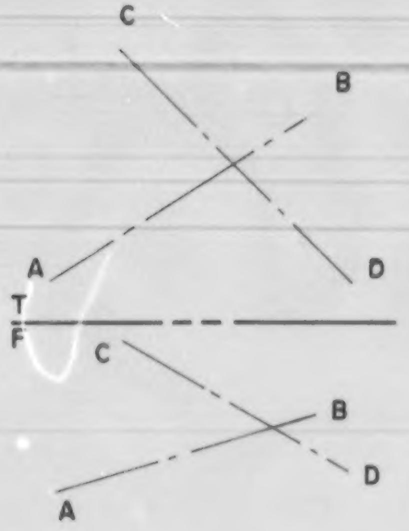
Problem B:



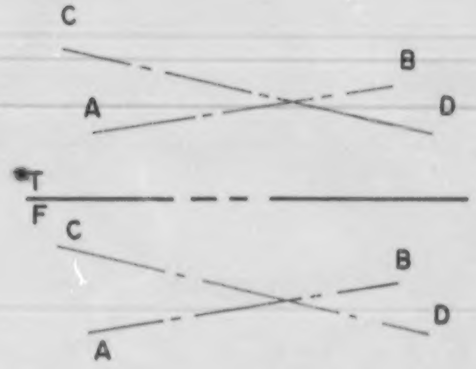
C
B
A
D
T
F
D
A
C
B

ASSIGNMENT SHEET #7

Problem C:


C
B
A
D
T
F
C
B
D
A

Problem D:


C
B
A
D
T
F
C
B
D
A

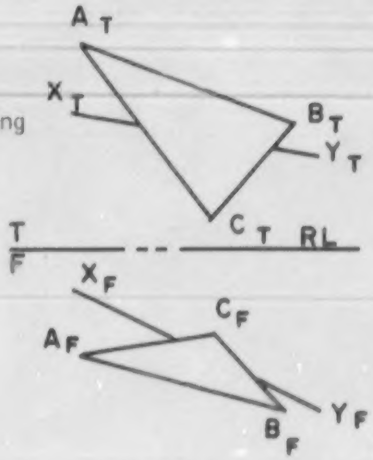
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #8–DETERMINE THE VISIBILITY OF A LINE AND A PLANE THAT CROSS IN SPACE

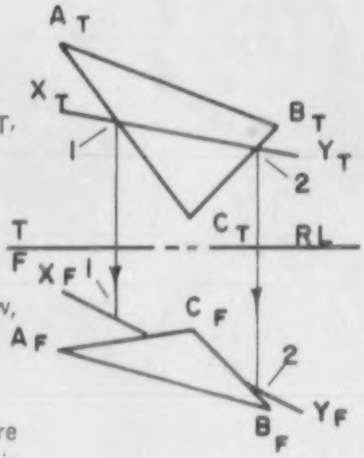
Premise: Determining the visibility of a line and a plane that cross in space is similar to that of crossing lines. The visibility of a line and a plane that cross in space can be determined by using the procedure in the following example.

Examples:

1. Use given two views of plane ABC and line XY crossing in space

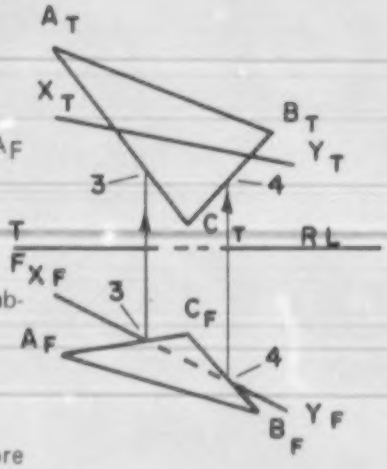


2. Determine visibility of line in top view
   a. Label the crossing of line X_T, Y_T with plane A_T, B_T, C_T, as 1, 2
   b. Project the crossing points to the front view, establishing points 1, 2
   c. The projected lines intersect line X_F, Y_F before they intersect the plane; therefore, line X_F, Y_F is nearer to top view and is visible



ASSIGNMENT SHEET #8

3. Determine visibility of line in front view



   a. Label the crossing of line X_F Y_F with plane A_F B_F C_F as 3, 4

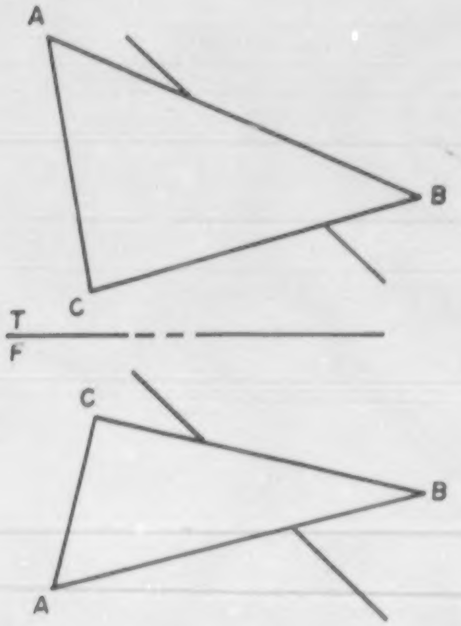
   b. Project the crossing points to the top view, establishing points 3, 4

   c. The projected lines intersect the plane before they intersect the line; therefore, line X_F Y_F is hidden in the front view

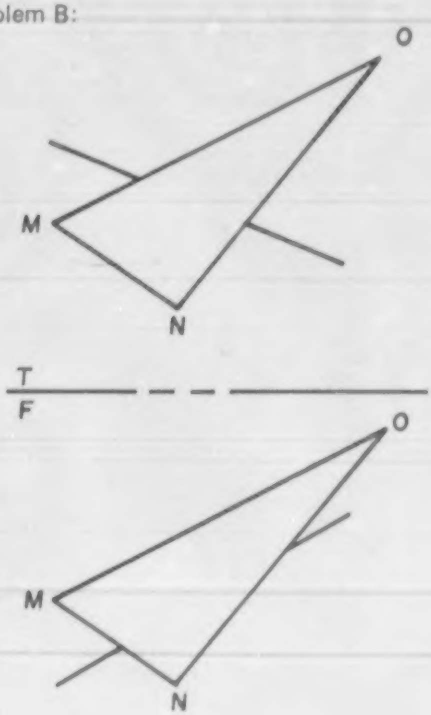
   (NOTE: The plane is nearer to the front view and line XY crosses behind plane ABC.)

Directions: Complete the following two view drawings showing the visible and hidden lines. Leave projection lines.

Problem A:

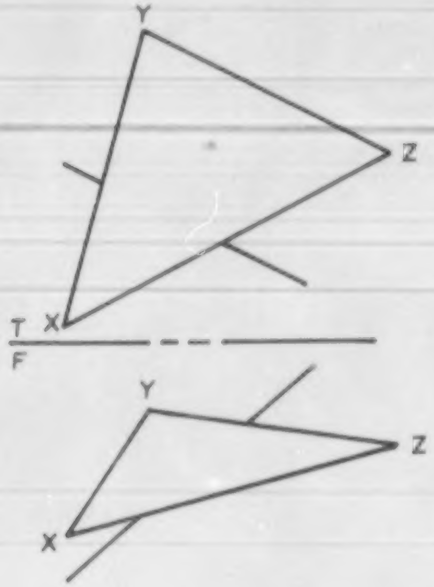


Problem B:

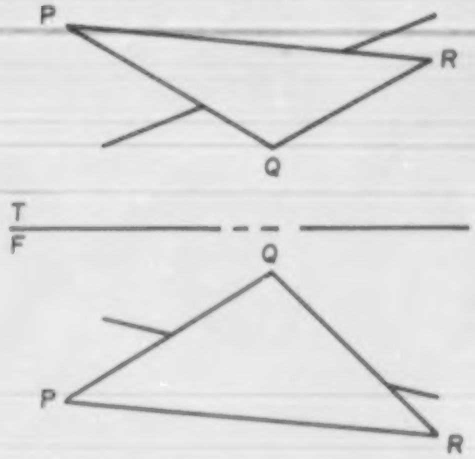


ASSIGNMENT SHEET #8

Problem C:



Problem D:



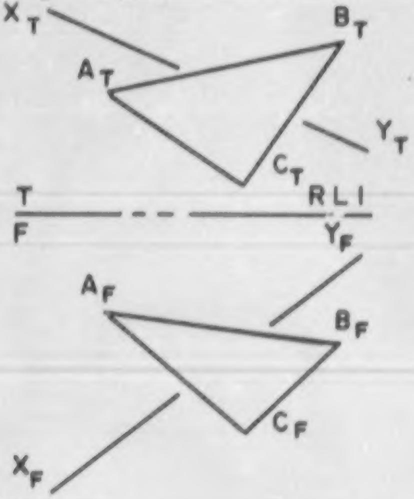
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #9--LOCATE PIERCING POINT OF A LINE AND A PLANE

Premise: The piercing point of a line and a plane may be located by constructing a primary auxiliary view. An edge view of a plane and a line is projected from one of the plane and a line is projected from one of the principal views to show intersection. The point where the line intersects the plane is projected to the principal views. The procedure for determining visibility of line is given in Assignment Sheets 7 and 8. The piercing point of a line and a plane can be located by using the procedure in the following example.

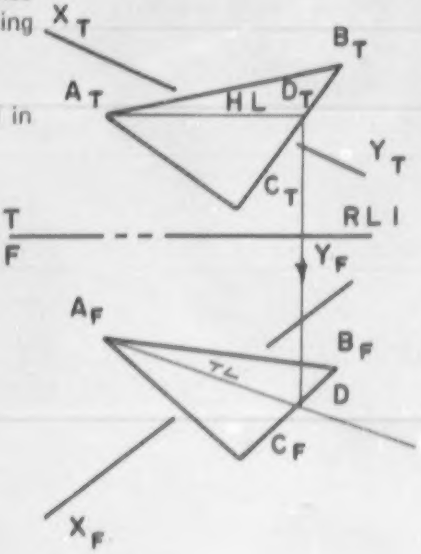
Example:

1. Use given views of line XY and plane ABC



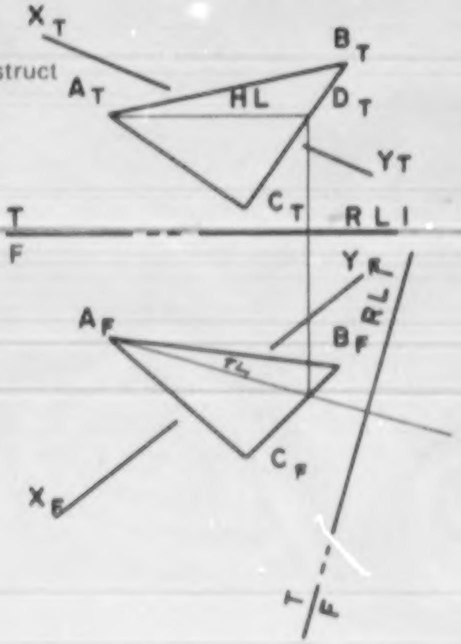
2. Construct line $A_T D_T$ in top view parallel to reference line RL1; then project point D_T to front view, locating point D_F

   (NOTE: Line AD may be constructed parallel to RL1 in front view.)

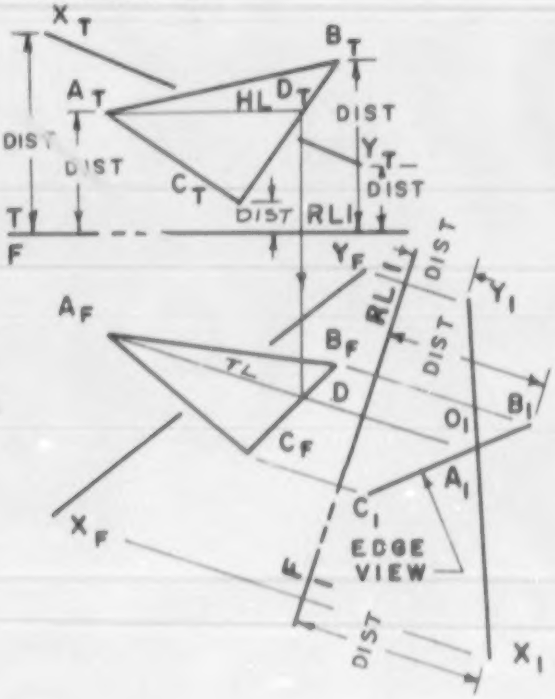


ASSIGNMENT SHEET #9

3. Project true length line $A_F D_F$ as line of sight; construct reference line RL2 perpendicular to it

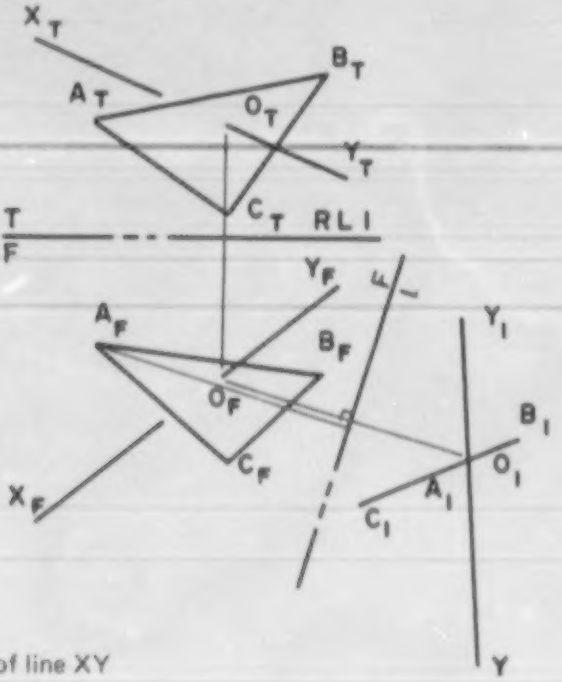

X T
B T
A T
HL
D T
YT
C T
R L I
T
F
Y F
RL2
A F
B F
TL
C F
X F
T
F

4. Project points A_F, B_F, C_F, X_F, Y_F to auxiliary and transfer distances from top view to establish piercing point O_1

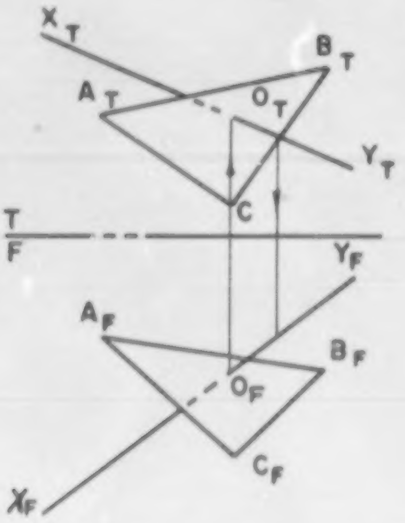

X T
B T
A T
HL
D T
DIST
DIST
DIST
Y T
DIST
C T
DIST
RL1
T
F
Y F
DIST
RL1
Y 1
A F
B F
DIST
TL
D
B 1
O 1
C F
A 1
C 1
EDGE VIEW
X F
F
DIST
X 1

ASSIGNMENT SHEET #9

5. Project the piercing point to front and top views


X_T
B_T
A_T
O_T
Y_T
C_T
RL1
T
F
Y_F
A_F
B_F
O_F
C_F
X_F
Y_1
B_1
O_1
A_1
C_1
Y

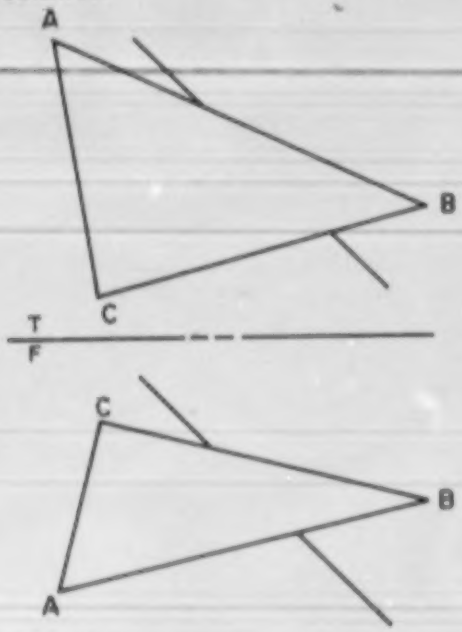
6. Determine visibility of line XY


X_T
B_T
A_T
O_T
Y_T
C
T
F
Y_F
A_F
B_F
O_F
C_F
X_F

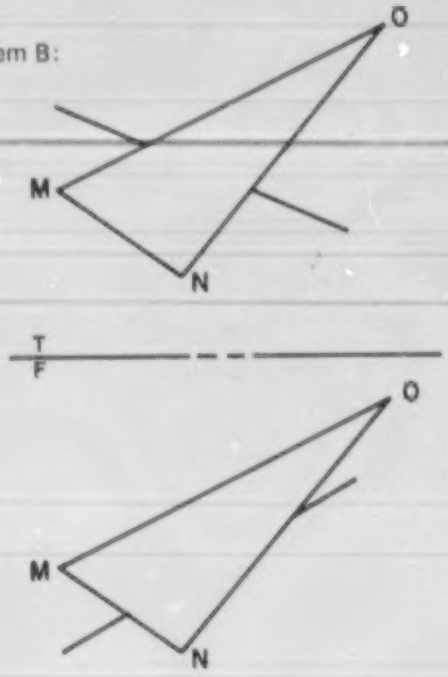
ASSIGNMENT SHEET #9

Directions: Determine piercing point of a line and a plane in the following problems. Leave construction lines and determine visibility of lines.

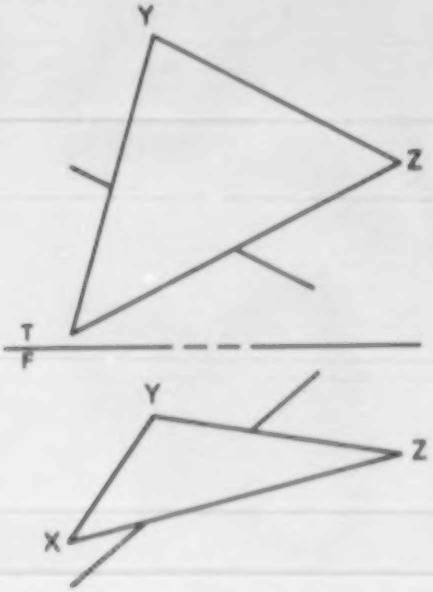
Problem A:



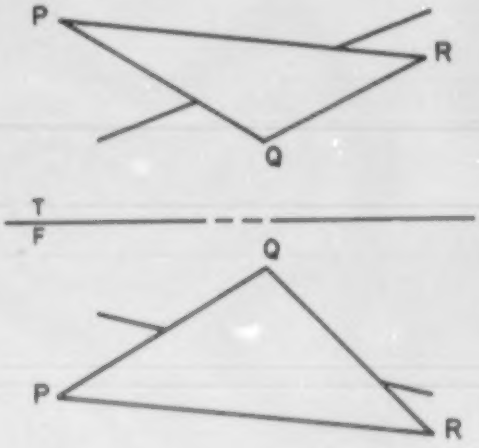
Problem B:



Problem C:



Problem D:



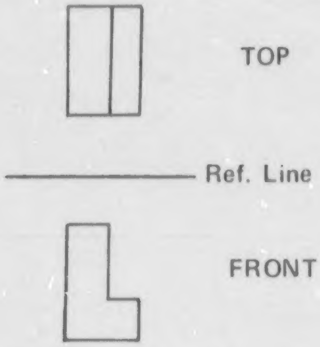
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #10--CONSTRUCT A SECONDARY AUXILIARY VIEW OF AN OBJECT

Premise: An infinite number of views can be taken from any view of an object. The first auxiliary off the orthographic view is called a primary auxiliary view. An auxiliary off a primary auxiliary view is called a secondary auxiliary. A secondary auxiliary view can be constructed by using the procedure in the following example. An auxiliary can be drawn of any angle desired or needed for this procedure.

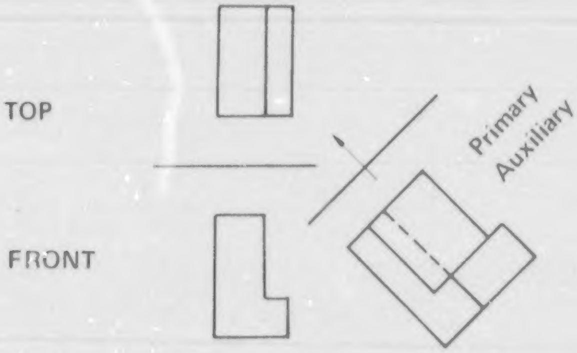
Example:

1. Use given top and front view of a simple object; assume a line of sight at angle indicated



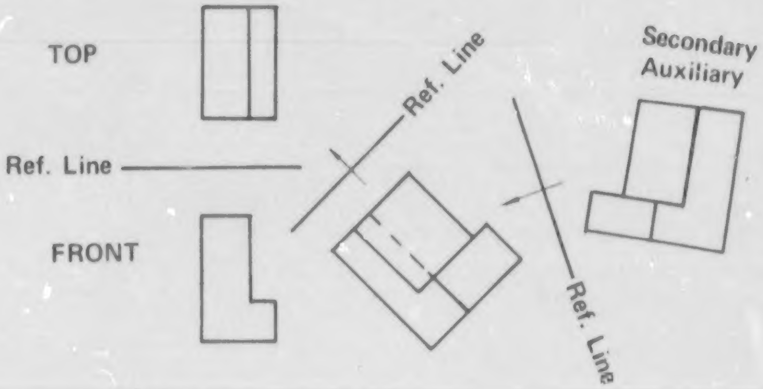
2. Project each point to auxiliary view and transfer point distances from front view

   (NOTE: Always skip a view for transfer of measurements.)



ASSIGNMENT SHEET #10

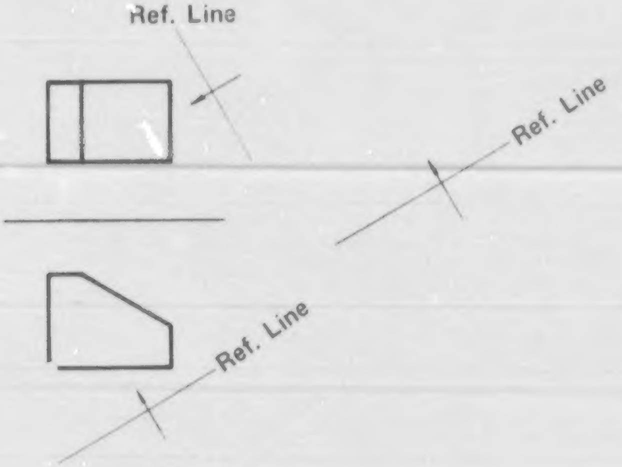
3. Assume another line of sight for view number two; transfer dimensions from top view


TOP
Secondary Auxiliary
Ref. Line
Ref. Line
FRONT
Ref. Line

(NOTE: This process can go on indefinitely from any view in any direction. The principle is the same and the basic steps are the same.)

Directions: Construct auxiliary views at lines of sight indicated.

Problem:


Ref. Line
Ref. Line
Ref. Line

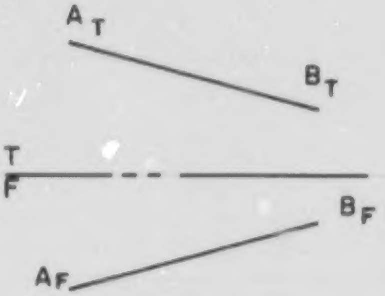
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #11--CONSTRUCT POINT VIEW OF A LINE

Premise: Determining the point view of a line is basic for projection of a secondary auxiliary view. The procedure given in the example is for determining point view of only one line. The procedure for finding point view of oblique lines is the same. Point view of a line can be constructed by using the procedure in the following example.

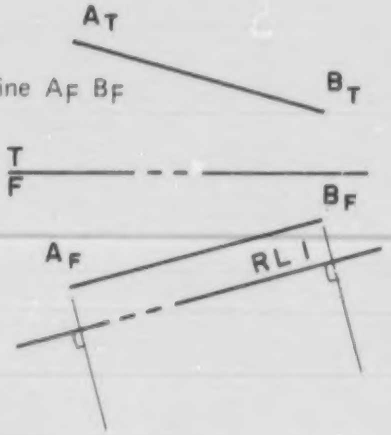
Example:

1. Use given top and front view of line AB

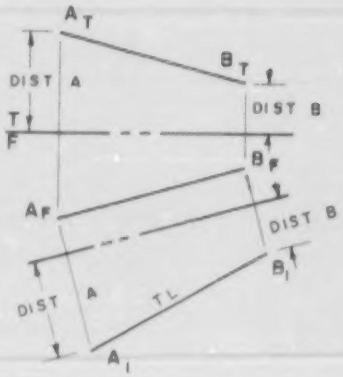


2. Construct reference line RL1 parallel to line A_F B_F

   (NOTE: Top view could have been used.)

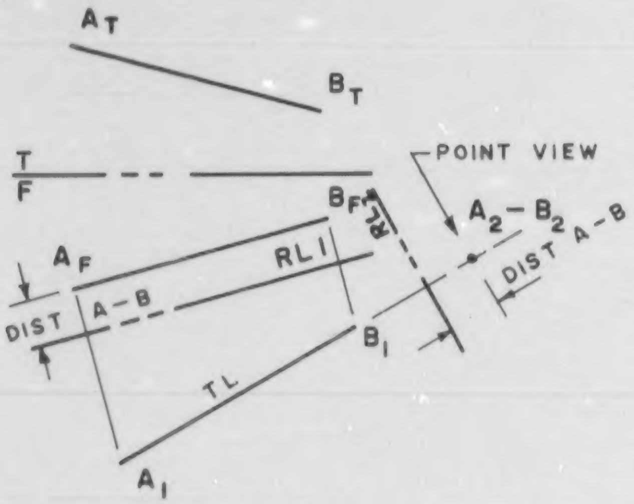


3. Find true length of line A_F T_F by projecting end points from front view, then transfer from top view



ASSIGNMENT SHEET #11

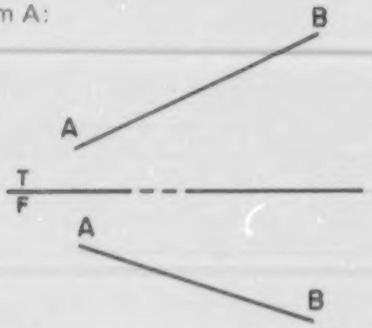
4. Construct reference line RL2 perpendicular to true length line A_1 B_1


A_T
B_T
T
F
POINT VIEW
B_F
RL2
$A_2 - B_2$
DIST A-B
A_F
RL1
DIST A-B
B_1
TL
A_1

5. To find point view of line, transfer distance from front view and project line A_1 B_1 to secondary auxiliary view

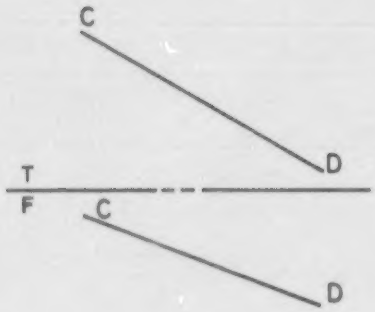
Directions: Construct a point view of a line in the following problems. Label end points of lines in construction. Leave construction lines.

Problem A:



ASSIGNMENT SHEET #11

Problem B:



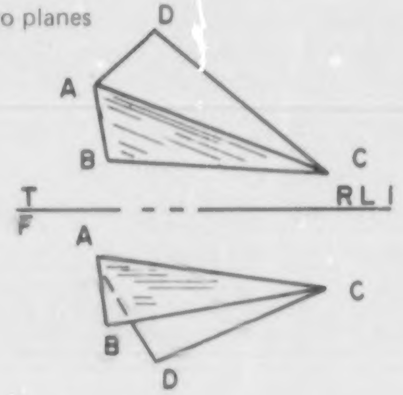
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #12–DETERMINE TRUE ANGLE BETWEEN TWO PLANES IN A SECONDARY AUXILIARY

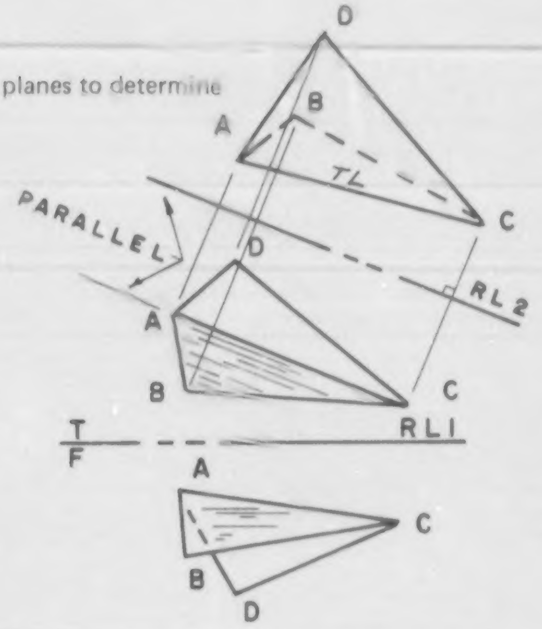
Premise: When the line of intersection between two planes is an oblique line, a secondary auxiliary view is required. True angle between two planes in a secondary auxiliary can be determined by using the procedure in the following example.

Example:

1. Use given top and front views of the two planes

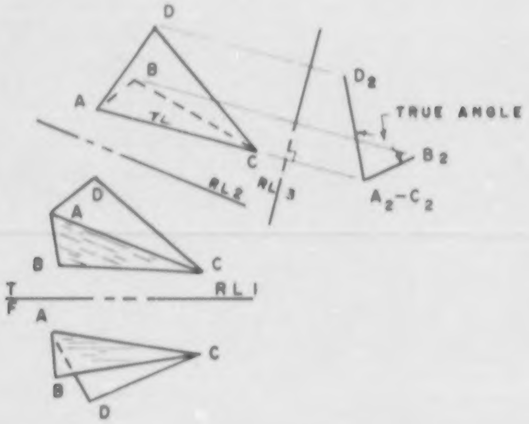


2. Construct primary auxiliary view of planes to determine true length of line of intersection



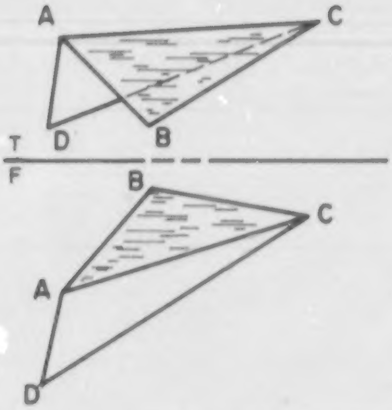
ASSIGNMENT SHEET #12

3. Construct a secondary auxiliary view to determine point view of line of intersection
4. Locate points B_2 D_2 by projecting from primary auxiliary view; transfer distances from top view
5. Measure true angle between line of intersection of two planes with protractor


D
B
A
TL
C
RL 2
RL 3
D2
TRUE ANGLE
B2
A2-C2
D
A
B
C
T
F
RL 1
A
C
B
D

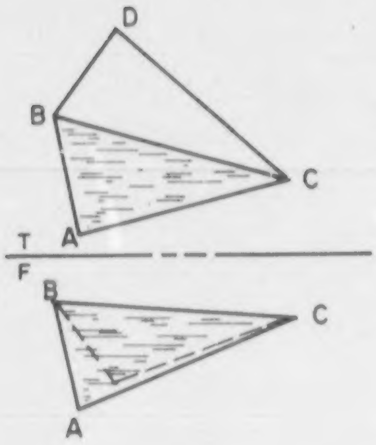
Directions: Determine the true angle between two planes in the following problems. Measure angle with protractor or drafting machine. Leave construction lines.

Problem A:


A
C
T
D
B
F
B
C
A
D

ASSIGNMENT SHEET #12

Problem B:



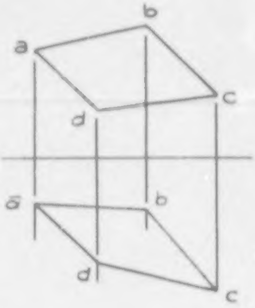
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #13--CONSTRUCT A TRUE SIZE AUXILIARY OF AN OBLIQUE PLANE

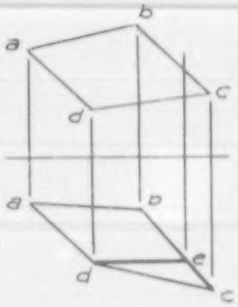
Premise: An oblique plane is at an angle to three principal views. It will not appear true size in any of the views; therefore, it is necessary to draw an auxiliary view of it. Oblique planes are not uncommon on many types of drawings. A simple example is given, but the basic principles will apply for all situations. A true size auxiliary of an oblique plane can be constructed by using the procedure in the following example.

Example:

1. Use given surface abcd, top and front view

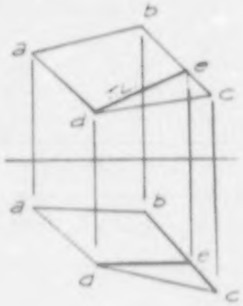


2. Construct a horizontal line either in the top or front view at point a or c in top or point b or d in front; in this example use point d in front and extend it horizontally to line bc making a new point e

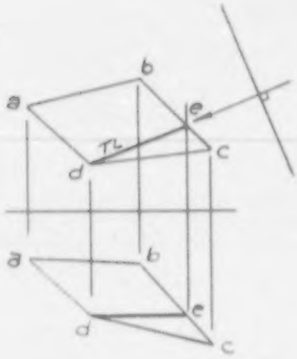


ASSIGNMENT SHEET #13

3. Project point e to top view until it crosses line bc and draw line d-e in top; line d-e is true length

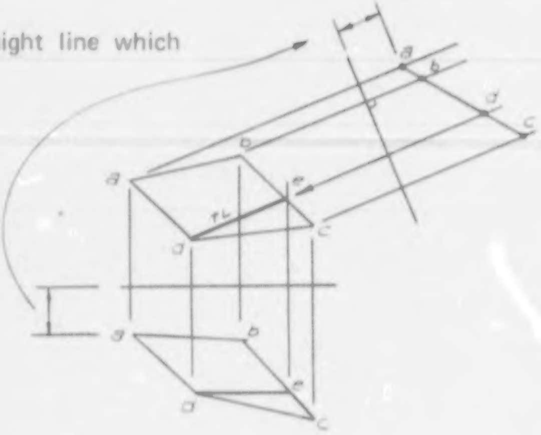

b
a
e
TL
c
d
a
b
e
d
c

4. Assume a line of sight looking into the end of line d-e; draw reference line perpendicular to line of sight


b
a
e
TL
c
d
a
b
e
d
c

5. Project points abcd through reference line and transfer measurements from front view

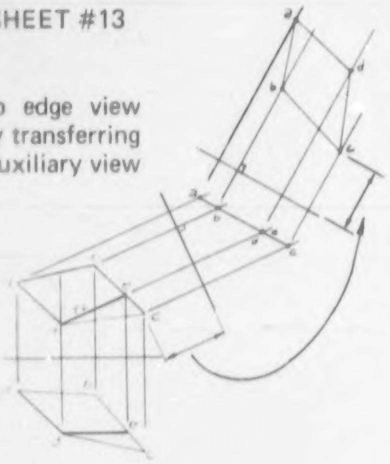
(NOTE: Points abcd will form a straight line which is an edge view of plane.)


a
b
d
c
b
a
e
TL
c
d
a
b
e
d
c

ASSIGNMENT SHEET #13

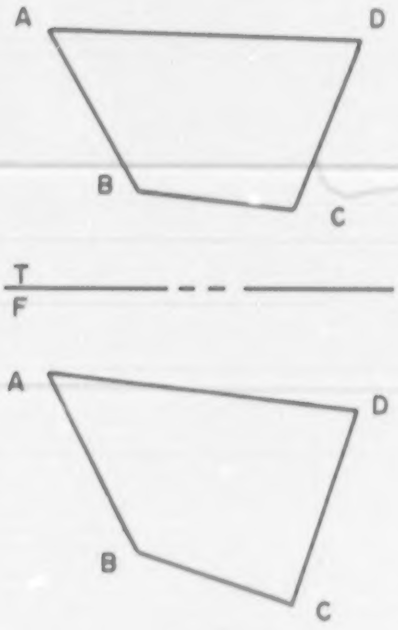
6. Assume a line of sight perpendicular to edge view and draw a true size view of plane abcd by transferring point distances from top view to true size auxiliary view

7. Connect points to form true size of plane



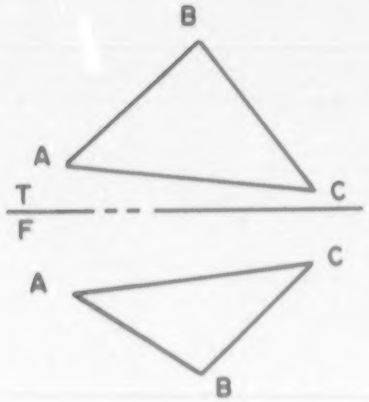
Directions: Construct true size view of the oblique planes in the problems given.

Problem A:

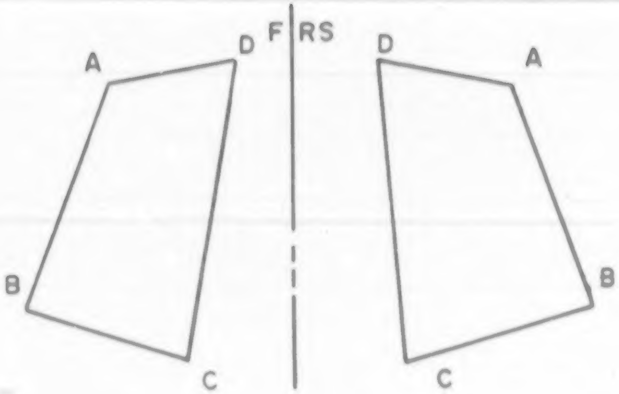


ASSIGNMENT SHEET #13

Problem B:



Problem C:


F
RS
A
D
D
A
B
C
B
C

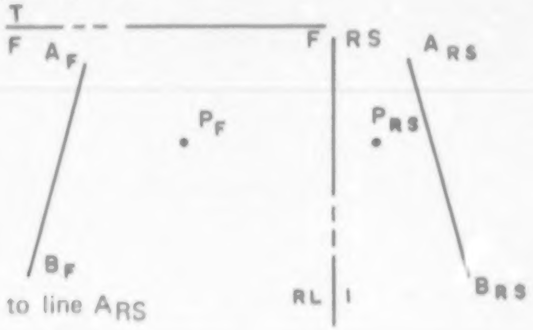
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #14--DETERMINE SHORTEST DISTANCE BETWEEN A POINT AND A LINE

Premise: In the manufacture of equipment, it is necessary to determine the clearance distance between parts. The shortest distance is determined by secondary auxiliary view. A distance between a point and a line can be determined by using the procedure in the following example.

Example:

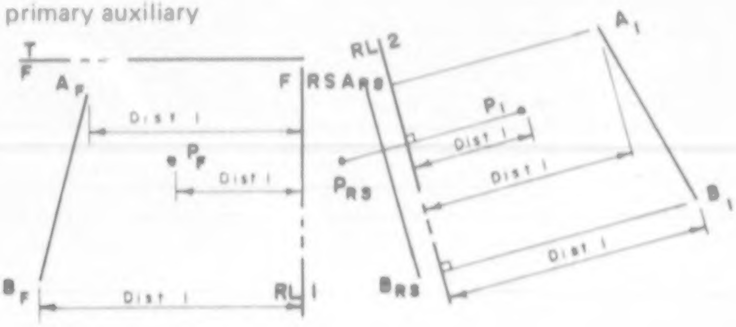
1. Use given front and right side views of the line and point


T
F
A_F
P_F
B_F
F
RS
A_{RS}
P_{RS}
B_{RS}
RL 1

2. Construct reference line RL2 parallel to line A_{RS} B_{RS}

3. Construct true length of line AB by projecting end points from right side view, then transfer distance from front view

4. Construct point P in primary auxiliary

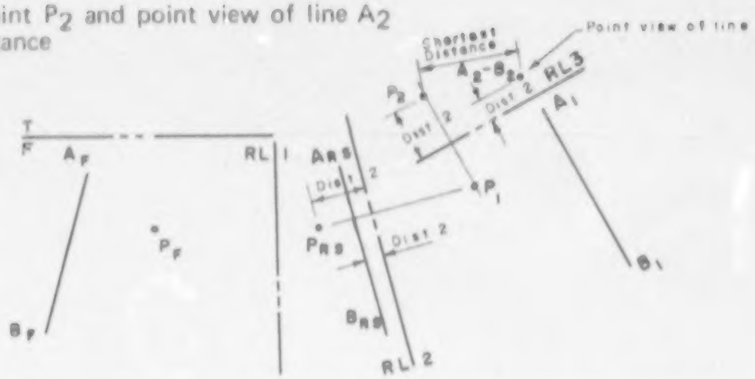

T
F
A_F
Dist 1
P_F
Dist 1
B_F
Dist 1
F
RS
A_{RS}
RL 1
RL 2
A_1
P_1
Dist 1
Dist 1
P_{RS}
Dist 1
B_1
Dist 1
B_{RS}

5. Construct reference line RL3 perpendicular to line A_1B_1

6. Transfer distances M_1 N_1 from primary auxiliary to establish point P_2 and point view of line A_2 B_2

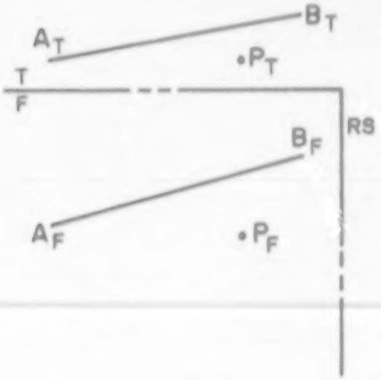
ASSIGNMENT SHEET #14

7. Distance between point P_2 and point view of line A_2 B_2 is the shortest distance

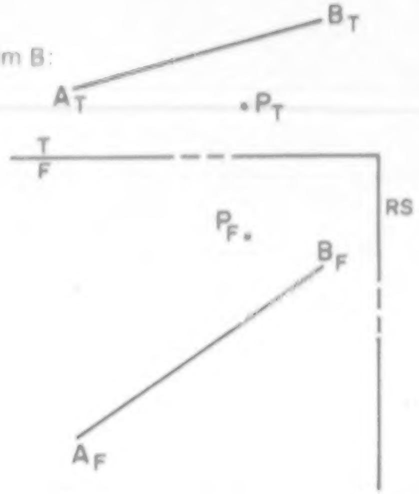

Point view of line
Shortest Distance
A_2-B_2
P_2
RL3
A_1
Dist 2
Dist 2
T
F
A_F
RL 1
A_{RS}
Dist 1
2
P_1
P_F
P_{RS}
Dist 2
B_1
B_F
B_{RS}
RL 2

Directions: Using secondary auxiliary procedure, determine shortest distance between a point and a line in the problems given. Measure distance with full size scale.

Problem A:


A_T
B_T
P_T
T
F
RS
B_F
A_F
P_F

Problem B:


B_T
A_T
P_T
T
F
RS
P_F
B_F
A_F

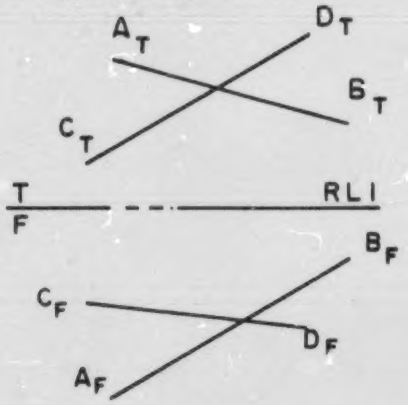
AUXILIARY VIEWS
UNIT VI

ASSIGNMENT SHEET #15--DETERMINE SHORTEST DISTANCE BETWEEN TWO SKEW LINES

Premise: Crossing lines in space are not necessarily intersecting lines. Sometimes it becomes necessary to determine clearance distance between two lines. Shortest distance between two skew lines in a secondary auxiliary can be determined by using the procedure in the following example.

Example:

1. Use given top and front views of two skew lines

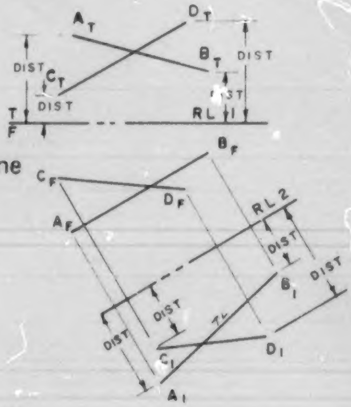


A_T
D_T
B_T
C_T
T
F
RL I
B_F
C_F
D_F
A_F

2. Construct reference line RL 2 parallel to line A_F B_F in front view

   (NOTE: Top view may be used if reference line is constructed parallel to one of the lines.)

3. Construct primary auxiliary of line A_F B_F to determine true length line



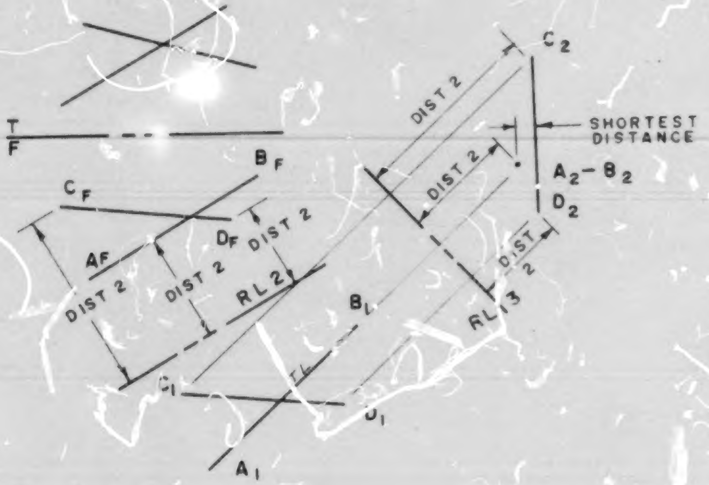
A_T
D_T
DIST
B_T
DIST
C_T
DIST
DIST
T
F
RL I
B_F
C_F
D_F
A_F
RL 2
DIST
DIST
B_1
DIST
TL
DIST
D_1
C_1
A_1

4. Construct reference line RL3 perpendicular to true length line

ASSIGNMENT SHEET #15

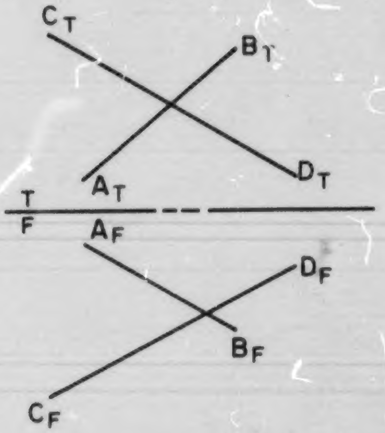
5. Transfer distances from front view to secondary auxiliary view, then project points from primary auxiliary to secondary auxiliary to establish line and point view of a line

6. Distance between line $C_2 D_2$ and point view of line $A_2 B_2$ is shortest distance


T
F
B_F
C_F
A_F
D_F
DIST 2
DIST 2
DIST 2
RL 2
B_1
C_1
TL
D_1
A_1
DIST 2
DIST 2
C_2
SHORTEST DISTANCE
A_2-B_2
D_2
DIST 2
RL 3

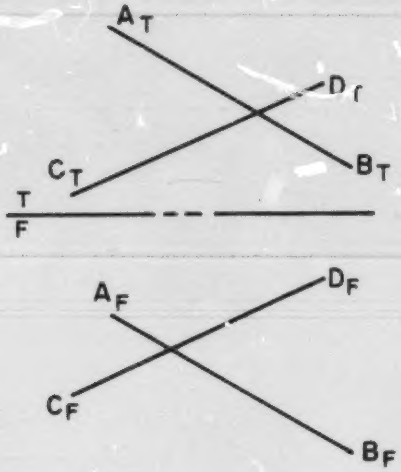
Directions: Determine shortest distance between two skew lines in the problems given. Measure the distance with full size scale.

Problem A:


C_T
B_T
A_T
D_T
T
F
A_F
D_F
B_F
C_F

ASSIGNMENT SHEET #15

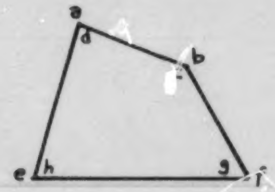
Problem B:


A_T
D_T
B_T
C_T
T
F
A_F
D_F
C_F
B_F

AUXILIARY VIEWS
UNIT VI

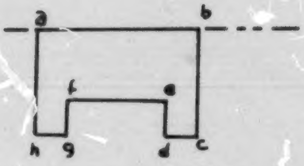
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

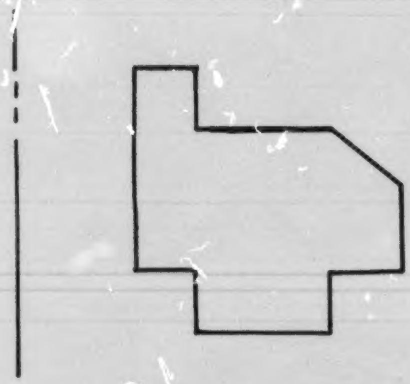


Assignment Sheet #2

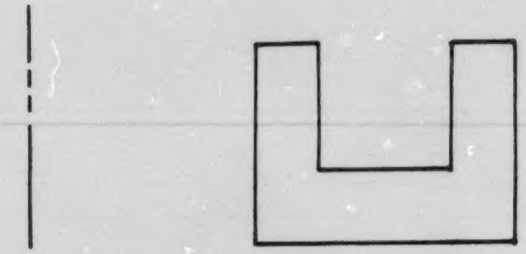
A.



B.

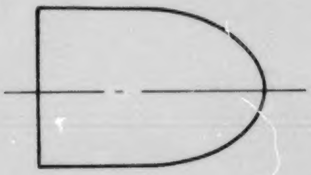


C.

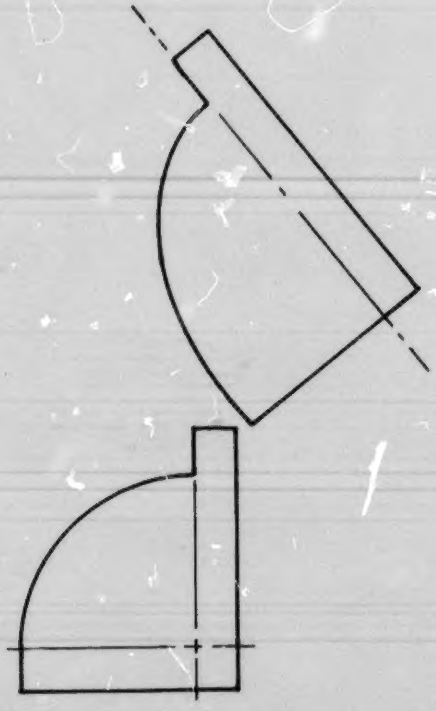


Assignment Sheet #3

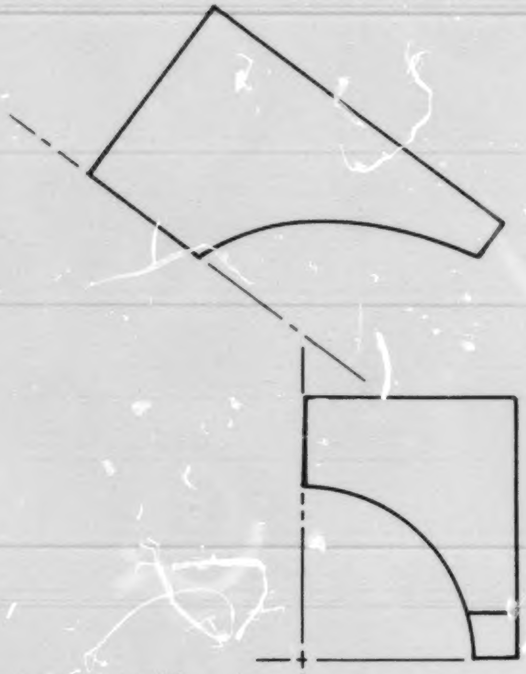
A.



B.

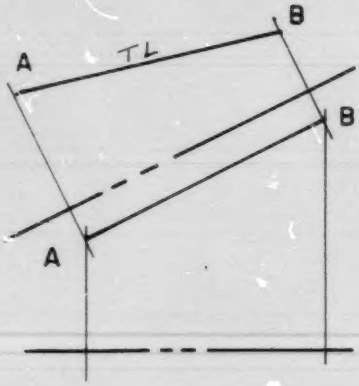


C.

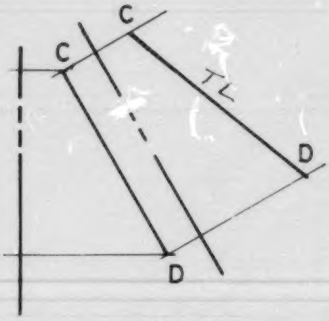


Assignment Sheet #4

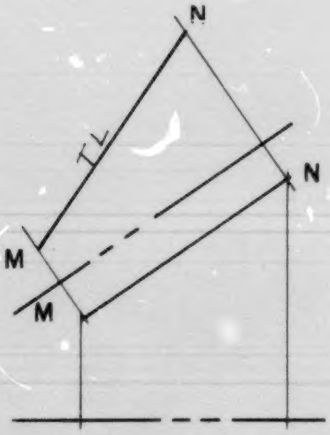
A.



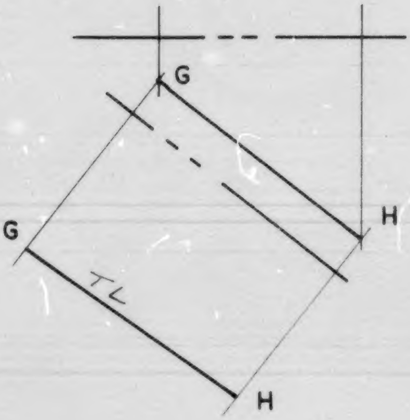
B.



C.

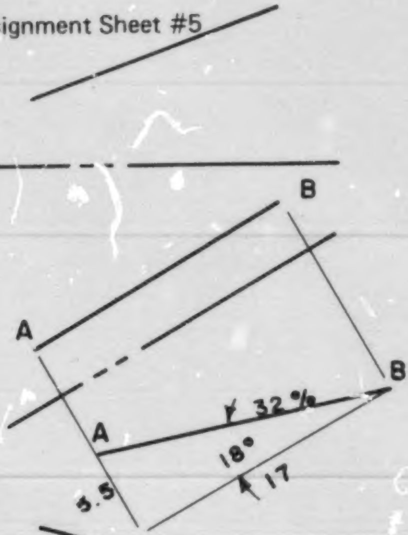


D.

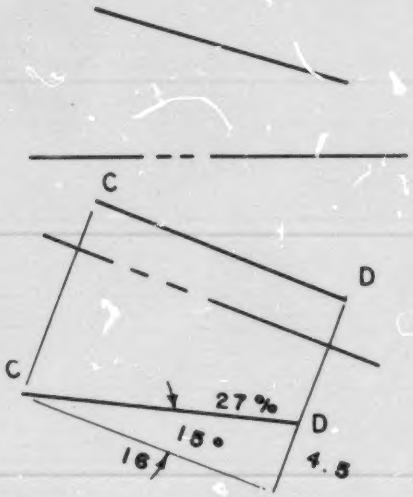


Assignment Sheet #5

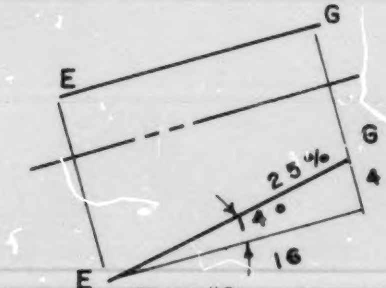
A.


B
A
B
A
32 %
18°
17
3.5

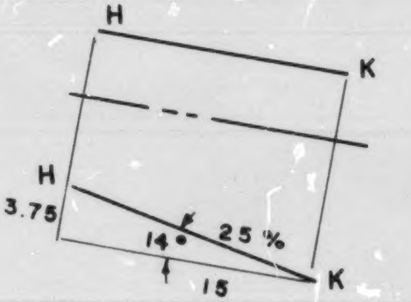
B.


C
D
C
27 %
D
15°
16
4.5

C.

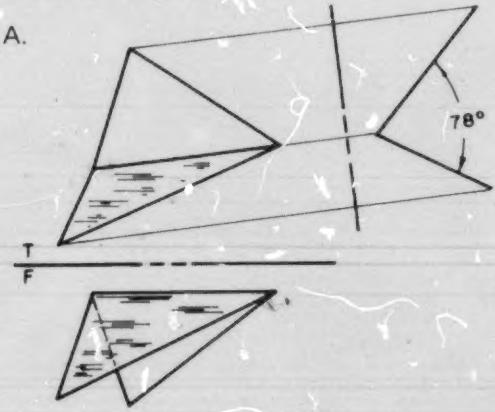

G
E
G
25 %
4
14°
16
E

D.

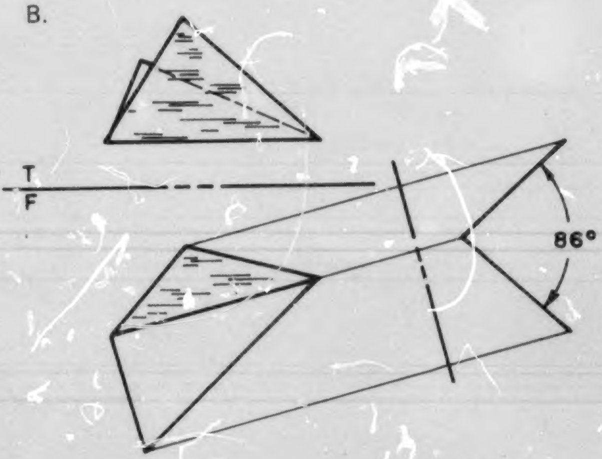

H
K
H
3.75
14°
25 %
15
K

Assignment Sheet #6

A.

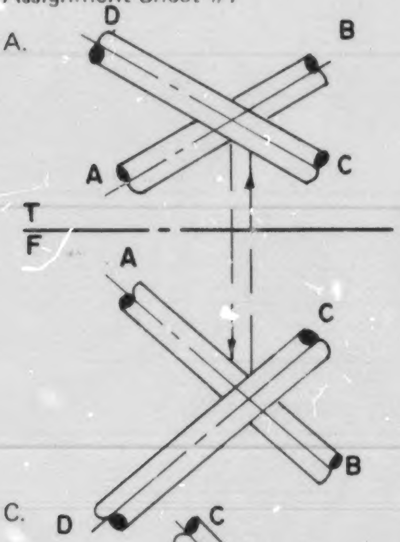


B.

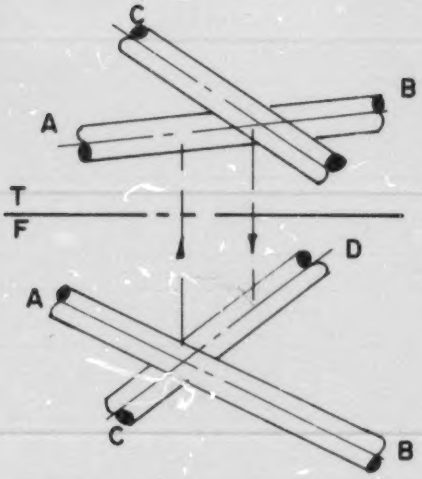


Assignment Sheet #7

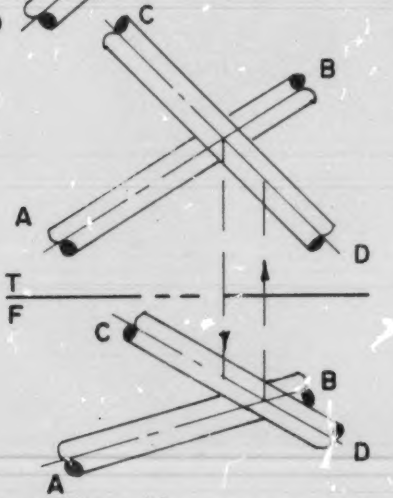
A.


D
B
A
C
T
F
A
C
B
D

B.

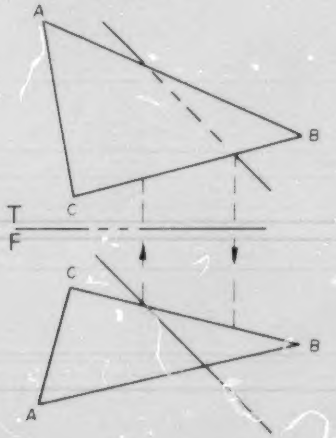


C.

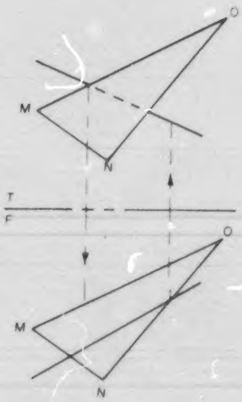

C
B
A
D
T
F
C
B
D
A

Assignment Sheet #8

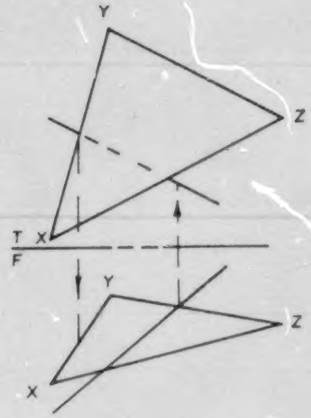
A.



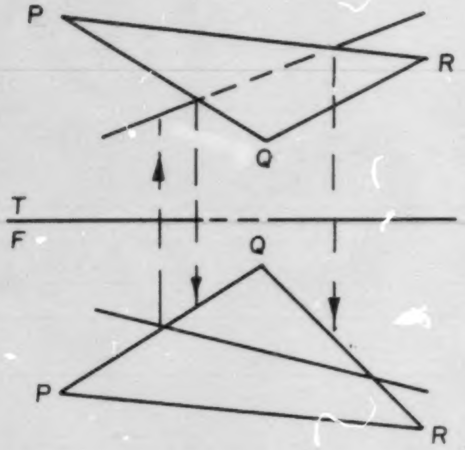
B.



C.

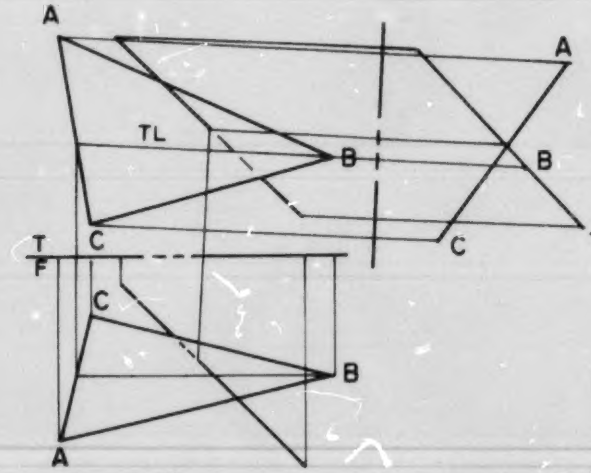


D.

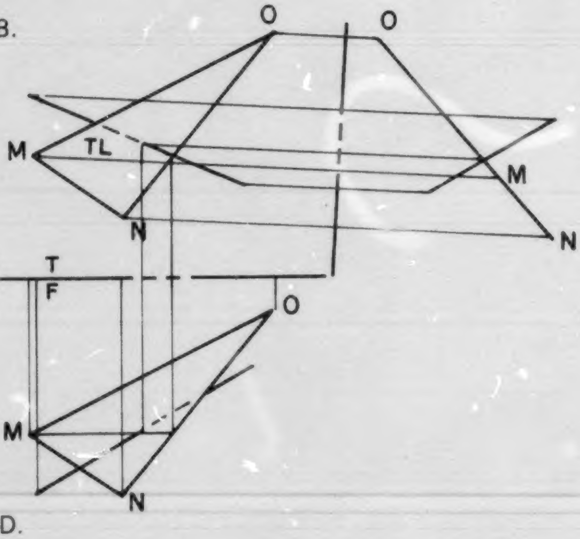


Assignment Sheet #9

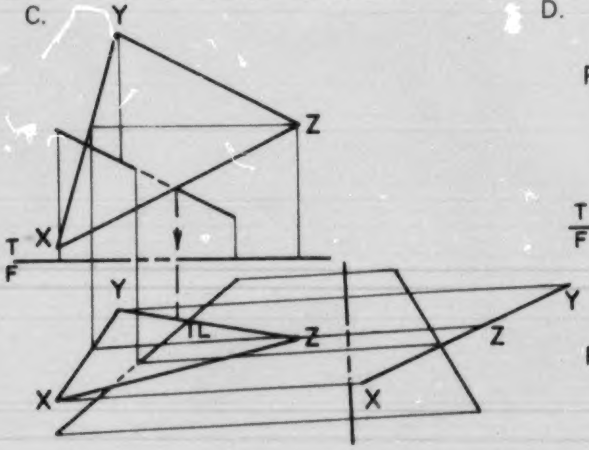
A.


A
A
TL
B
B
C
C
T
F
C
B
A

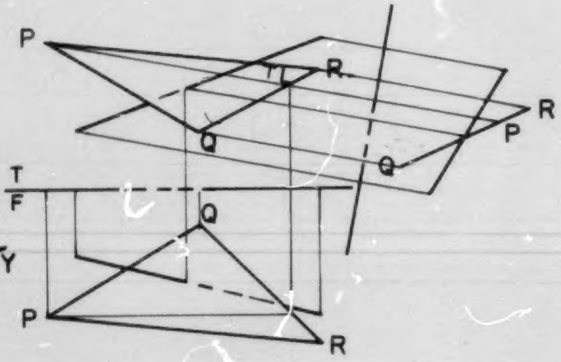
B.


O
O
M
TL
M
N
N
T
F
O
M
N

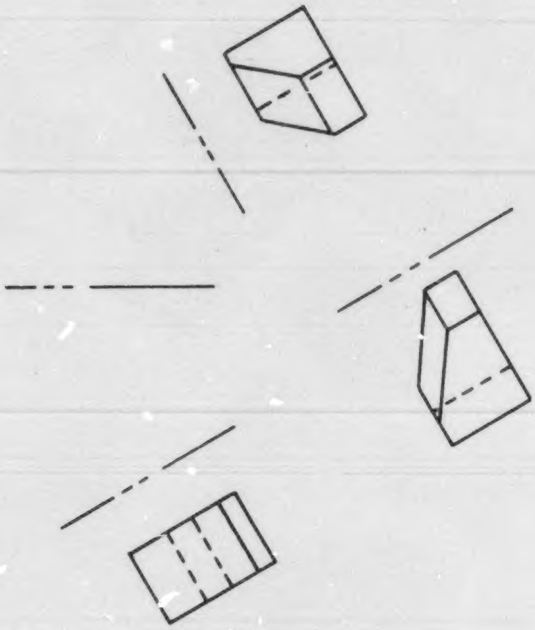
C.


Y
Z
X
T
F
Y
TL
Z
Y
Z
X
X

D.

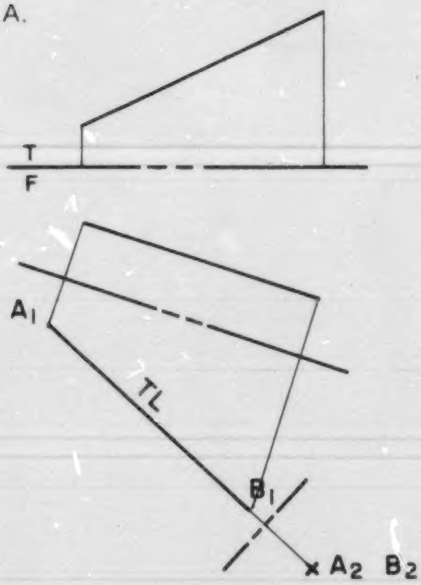

P
TL
R
R
Q
P
Q
T
F
Q
P
R

Assignment Sheet #10

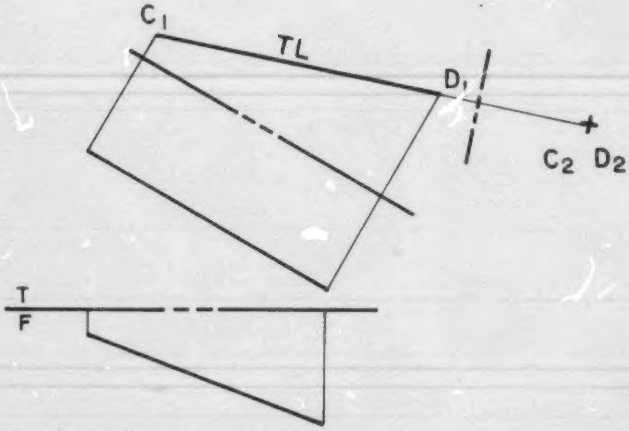


Assignment Sheet #11

A.

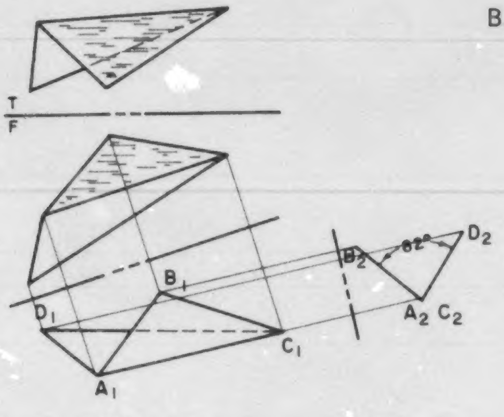

T
F
A1
TL
B1
A2
B2

B.

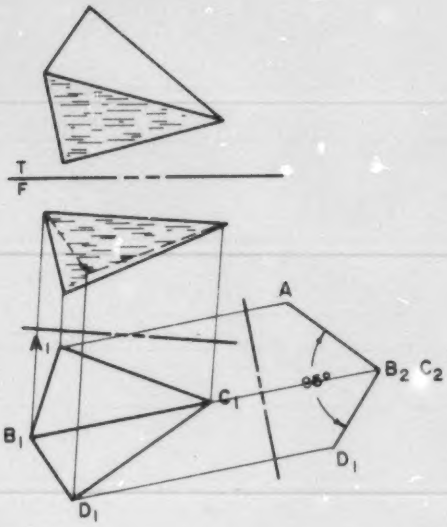

C1
TL
D1
C2
D2
T
F

Assignment Sheet #12

A.

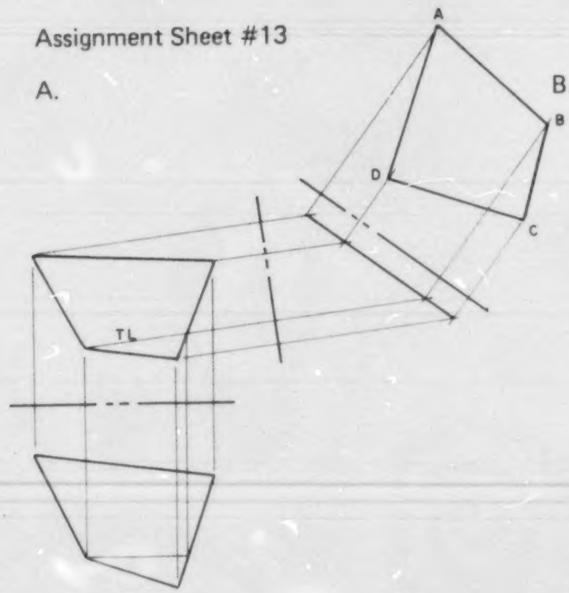

T
F
B₁
D₁
C₁
A₁
B₂
82°
D₂
A₂ C₂

B.

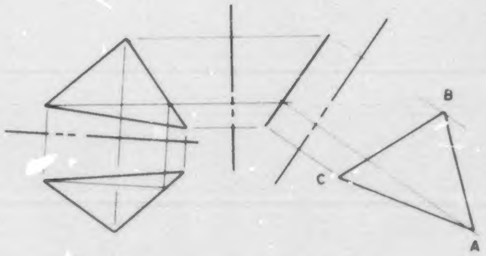

T
F
A
A₁
C₁
B₁
95°
B₂ C₂
D₁
D₁

Assignment Sheet #13

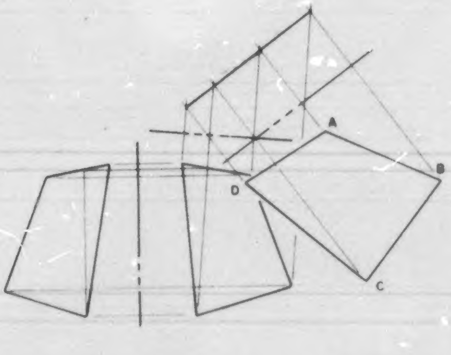
A.



B.

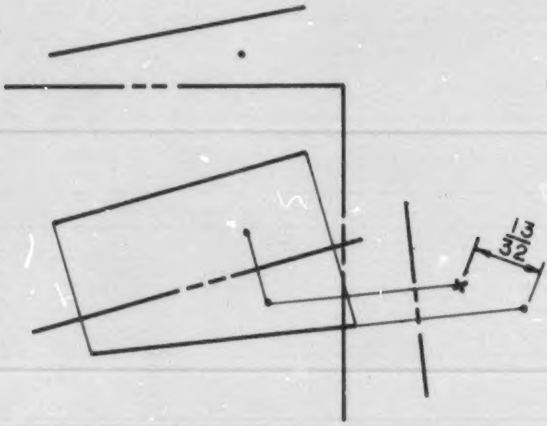


C.

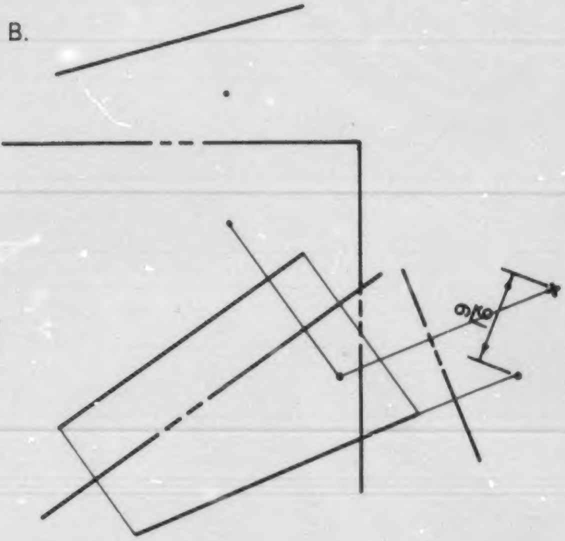


Assignment Sheet #14

A.

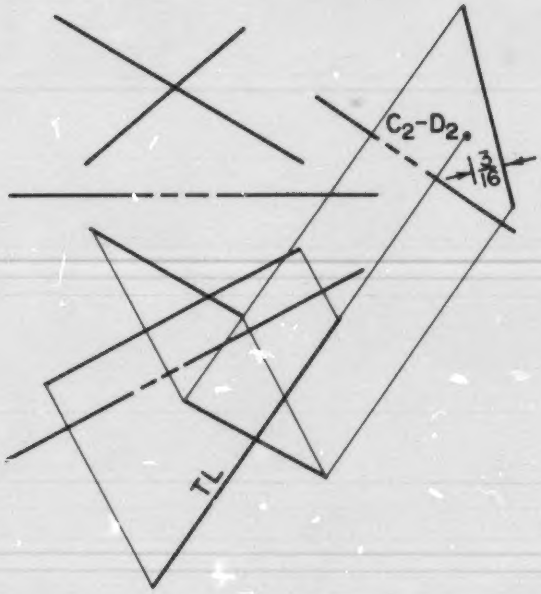


B.

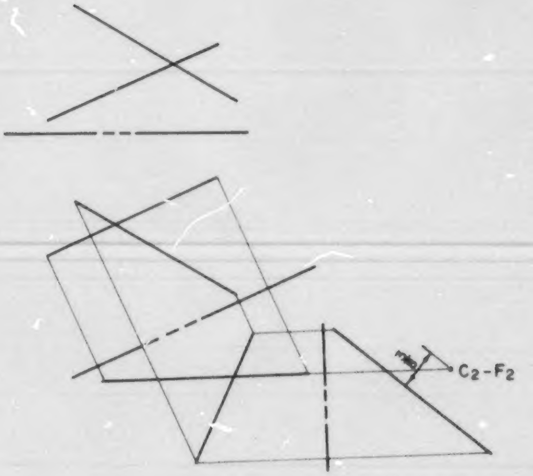


Assignment Sheet #15

A.



B.



AUXILIARY VIEWS
UNIT VI

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions

______ a. A line representing the inclined plane

______ b. A view or surface that is not perpendicular or right angle to the plane of projection

______ c. Direction from which an object is being viewed

______ d. Shows only the true size and detail of the inclined plane

______ e. A plane that is foreshortened in two principal viewing planes and edge view in one other principal viewing plane

______ f. To appear shorter to the eye than it actually is

______ g. A first projection of an inclined plane from one of the principal views

______ h. Oblique plane or line projected from a primary auxiliary view and one of the principal views

______ i. A surface that is shown in its actual size

______ j. A plane that is foreshortened in all three principal viewing planes

______ k. Take from one point or view and put in another view

______ l. A line that appears in its actual length

______ m. A line at 90° to a given plane of projection

______ n. A common line on back side, center, front side, or between views from which depth measurements are taken

______ o. A theoretical line between two views where viewing planes fold

______ p. Has same shape and size on opposite sides of a center line

______ q. Nonintersecting lines, not parallel to each other or to the principal views

1. Partial auxiliary
2. Inclined plane
3. True size
4. Symmetrical
5. Auxiliary view
6. Oblique plane
7. Perpendicular line
8. Edge view
9. Fold line
10. Line of sight
11. Slope
12. True length line
13. True angle
14. Foreshortened
15. Grade
16. Primary auxiliary view
17. Skew lines
18. Transfer
19. Reference line
20. Secondary auxiliary view

______r. The degree of inclination of a slope

______s. The angle a line makes with the horizontal plane

______t. An angle formed by two intersecting planes

2. Select true statements concerning uses of auxiliary views by placing an "X" in the appropriate blanks.

______a. Determine clearance distances and angles between manufactured parts

______b. Describe inclined surfaces of manufactured parts

______c. Determine percent of slope on pipelines, sewer lines, and grades on highway construction

______d. Determine percent of slope on geological formations

______e. Project any length of structural members

3. Name the views from which a primary auxiliary can be projected.

____

4. Select true statements concerning projection of measurements in a primary auxiliary view by placing an "X" in the appropriate blanks.

______a. Depth and height measurements are transferred with a scale or dividers in their true length from one of five views

______b. Make all measurement views from the edge view

______c. Length measurements are projected in their true length perpendicular from edge view to primary auxiliary

5. List the different locations of a reference line.

a. ____

b. ____

c. ____

d. ____

6. Select true statements concerning projection of measurements in a secondary auxiliary view by placing an "X" in the appropriate blanks.

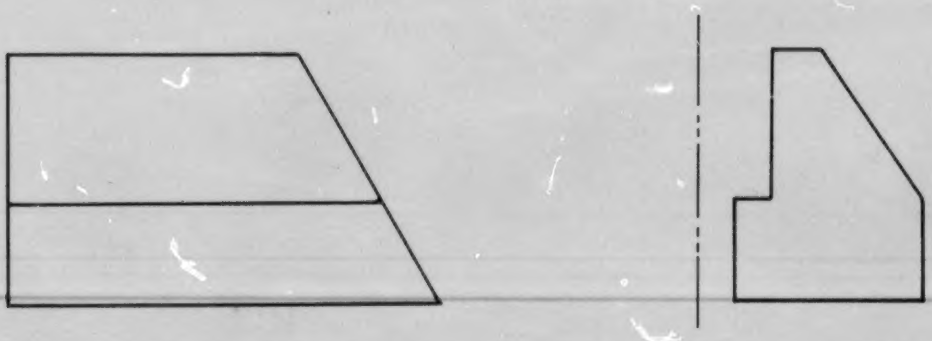
______a. Depth measurements are transferred from the edge view of one of the principal views

______b. Length measurements are projected from edge view

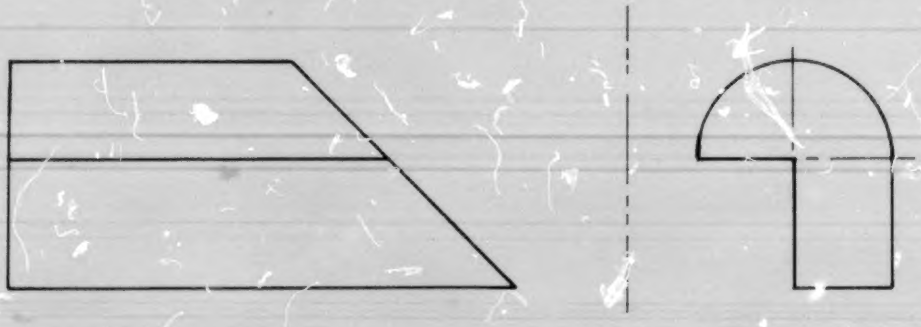
7. Demonstrate the ability to:
   - a. Label points and planes of a three view object.
   - b. Construct a primary auxiliary of an inclined plane.
   - c. Construct a true size auxiliary of a curved surface.
   - d. Construct true length of an oblique line.
   - e. Determine the true angle and slope of a line.
   - f. Determine the true angle between two planes.
   - g. Determine visibility of crossing skew lines in space.
   - h. Determine the visibility of a line and a plane that cross in space.
   - i. Locate piercing point of a line and a plane.
   - j. Construct a secondary auxiliary view of an object.
   - k. Construct point view of a line.
   - l. Determine true angle between two planes in a secondary auxiliary.
   - m. Construct a true size auxiliary of an oblique plane.
   - n. Determine shortest distance between a point and a line.
   - o. Determine shortest distance between two skew lines.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

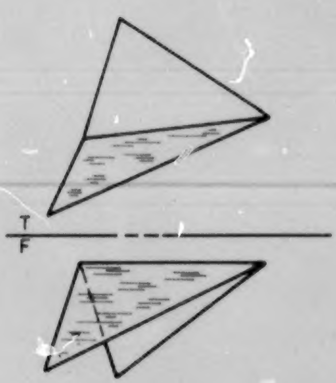
8. Construct the following auxiliary views.
   - a. Construct a primary auxiliary of an inclined plane.



b. Construct a true size auxiliary of a curved surface.



c. Determine the true angle between two planes.



AUXILIARY VIEWS
UNIT VI

ANSWERS TO TEST

1. a. 8
   b. 5
   c. 10
   d. 1
   e. 2
   f. 14
   g. 16
   h. 20
   i. 3
   j. 6
   k. 18
   l. 12
   m. 7
   n. 19
   o. 9
   p. 4
   q. 17
   r. 15
   s. 11
   t. 13

2. a, b, c

3. All six views

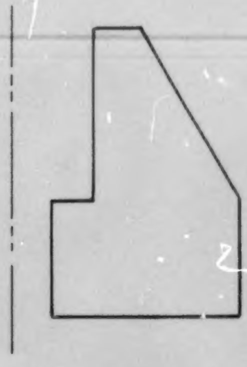
4. a, c

5. a. Back edge of view
   b. Center line
   c. Front edge of view
   d. Between views

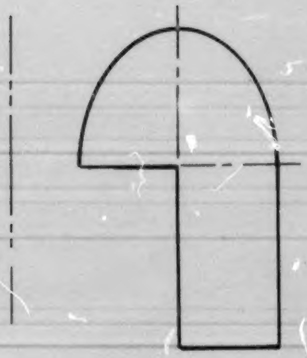
6. a

7. Evaluated to the satisfaction of the instructor

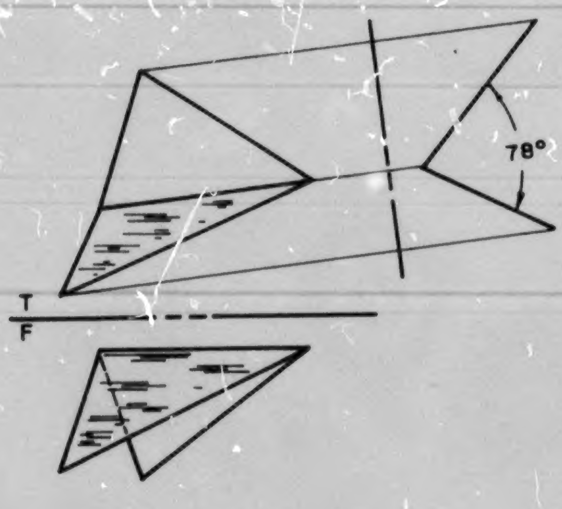
8. a.



b.



c.



SECTIONAL VIEWS
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to construct material symbols, full, half, offset, broken-out, removed, revolved, rib, aligned, and assembly sections. The student should also be able to construct conventional breaks. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to sectional views with their correct definitions.
2. Identify types of sectional views.
3. Identify material symbols in section.
4. Match types of sections with their correct uses.
5. Identify line thickness used in sectional drawings.
6. Select the most commonly used form of cutting plane lines.
7. Select true statements concerning general rules in sectioning.
8. Identify types of conventional breaks.
9. List common errors in making section lines.
10. Select true statements concerning use of unlined sections.
11. List methods used to aid equal spacing of section lining.
12. Select true statements concerning labeling sectional views.
13. Demonstrate the ability to:
    a. Construct various material symbols in section.
    b. Construct a full section of an object.
    c. Construct a half section of an object.
    d. Construct an offset section of an object.
    e. Construct a broken-out section of an object.
    f. Construct a removed section of an object.

g. Construct a revolved section of an object.

h. Construct a rib section of an object.

i. Construct an aligned section of an object with holes, ribs, or spokes.

j. Construct adjacent parts in assembly section.

k. Construct conventional breaks.

l. Construct an assembly section.

14. Construct various sectional views.

SECTIONAL VIEWS
UNIT VII

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Construct "cutaway models" of various objects to illustrate sectional views.

VII. Display cutaway parts of sectional views in classroom for students to inspect.

VIII. Discuss the use of sectional views.

IX. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
   A. Objective sheet
   B. Information sheet
   C. Transparency masters
      1. TM 1--Full Section
      2. TM 2--Half Section
      3. TM 3--Offset Section
      4. TM 4--Broken-Out Section
      5. TM 5--Removed Section
      6. TM 6--Revolved Section
      7. TM 7--Aligned Section
      8. TM 8--Aligned Section (Continued)
      9. TM 9--Rib Section
      10. TM 10--Assembly Section

11. TM 11--Material Symbols in Section
12. TM 12--Direction of Section Lines
13. TM 13--Materials in Assembly Section
14. TM 14--Visible Lines
15. TM 15--Hidden Lines
16. TM 16--Hidden and Symmetry Line Application
17. TM 17--Thin Sections
18. TM 18--Outline Section
19. TM 19--Errors in Making Section Lines

D. Assignment sheets

1. Assignment Sheet #1--Construct Various Material Symbols in Section
2. Assignment Sheet #2--Construct a Full Section of an Object
3. Assignment Sheet #3--Construct a Half Section of an Object
4. Assignment Sheet #4--Construct an Offset Section of an Object
5. Assignment Sheet #5--Construct a Broken-Out Section of an Object
6. Assignment Sheet #6--Construct a Removed Section of an Object
7. Assignment Sheet #7--Construct a Revolved Section of an Object
8. Assignment Sheet #8--Construct a Rib Section of an Object
9. Assignment Sheet #9--Construct an Aligned Section of an Object with Holes, Ribs, or Spokes
10. Assignment Sheet #10--Construct Adjacent Parts in Assembly Section
11. Assignment Sheet #11--Construct Conventional Breaks
12. Assignment Sheet #12--Construct an Assembly Section

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Giesecke, Frederick E., et al. *Technical Drawing*. New York: Macmillan Publishing Co., Inc., 1980.

B. Brown, Walter C. *Drafting for Industry*. South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

C. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design*. New York: Gregg Division/McGraw-Hill Book Co., 1979.

D. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing*. New York: Macmillan Publishing Co., Inc., 1968.

E. Spence, William P. *Drafting Technology and Practice*. Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

SECTIONAL VIEWS
UNIT VII

INFORMATION SHEET

I. Terms and definitions

A. Sectional view--The imaginary cutting away from front viewing portion of the object to show the interior detail

B. Full section--The cutting plane passes completely through an object and the cross section behind the cutting plane line is exposed to view

C. Section lining--A line symbol that is drawn on exposed cut surface; sometimes called cross hatching

D. Section symbols--Symbolic section lining used for indication of various materials

(NOTE: Do not use on microfilm drawings; use standard cast iron symbol.)

E. Cutting plane--An imaginary plane used to cut through an object

F. Half section--The cutting planes are passed at right angles to each other along the center lines and one-fourth of object is removed

G. Offset section--Has a cutting plane line to pick up features that are not along a common cutting plane

H. Broken-out section--An area broken out of a view that shows only a portion of that view in section

I. Removed section--A revolved section drawn off the principal view and placed in another convenient location

J. Revolved section--A cutting plane line is passed through an area and then the image is revolved 90° in position

K. Aligned section--Used to align features such as spokes, holes, and ribs along a common plane so that they can be detailed more easily

L. Thin section--Materials too thin for section lining are shown solid

M. Unlined section--Used for clarity in sections of assembly drawings of standard parts where the axis of the part lies in the cutting plane

(NOTE: When the axis lies at right angle to cutting plane, the part is sectioned.)

N. Conventional break--Used in making a shortened view of a long simple object

(NOTE: Do not remove holes from object in shortened view.)

INFORMATION SHEET

O. Assembly section--Shows all parts of an object as one unit and drawn using section lining to make the individual parts stand out

P. Outline sectioning--Section lines are shown along the borders of a large part for clarity and to save time

Q. Rib section--Method of not showing the ribs section lined eliminates the impression of solidity

R. Symmetry--Having the same shape and size on opposite sides of a center line

S. Subtitles--Labeling with capital letters the sectional view which has a removed section

II. Types of sectional views

A. Full section (Transparency 1)

B. Half section (Transparency 2)

C. Offset section (Transparency 3)

D. Broken-out section (Transparency 4)

E. Removed section (Transparency 5)

F. Revolved section (Transparency 6)

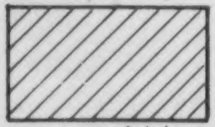
G. Aligned section (Transparencies 7 and 8)

H. Rib section (Transparency 9)

I. Assembly section (Transparency 10)

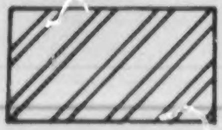
III. Material symbols in section (Transparency 11)

A. Cast iron



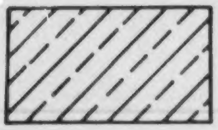
(NOTE: Where only one material is used on drawing, cast iron symbol is used and material noted in notes.)

B. Steel

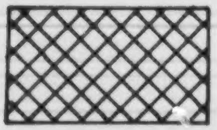


INFORMATION SHEET

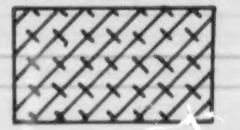
C. Brass, bronze, or copper



D. Zinc, lead, and alloys



E. Magnesium, aluminum and alloys



IV. Types of sections and their uses

A. Half section--To show both interior and exterior features of a symmetrical object

B. Revolved section--To show the true shape of the cross section of a long object such as a bar, spoke, rib, or arm

C. Offset section--To show features that are not in a straight line

D. Broken-out section--To show interior detail of objects where less than half section is required

E. Removed section--Used for clearness and for easier dimensioning

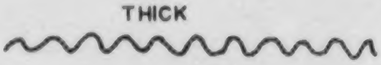
F. Full section--Replaces an exterior view in order to show some interior details

B. Aligned section--Used when true projection would be confusing for spokes, ribs, and holes

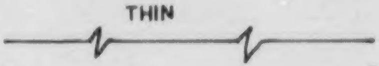
V. Line thickness used in sectional drawings

A. Section line, thin--

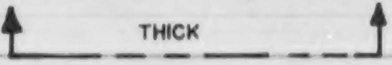
B. Short break line, thick--



C. Long break line, thin--

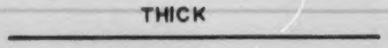


D. Cutting plane line, thick--

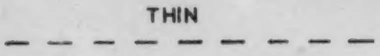


INFORMATION SHEET

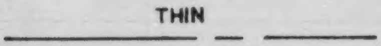
E. Visible line, thick--



F. Hidden line, thin--

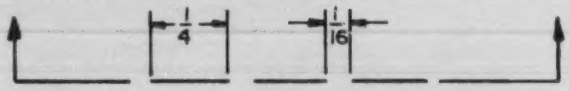


G. Center line, thin--

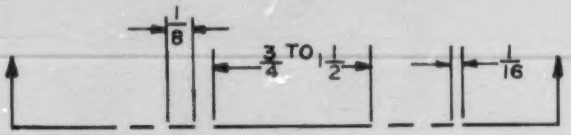


VI. Forms of cutting plane lines

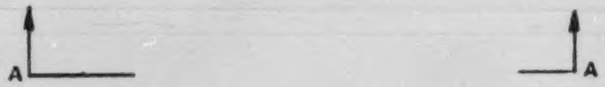
A.



B. Most commonly used form--



C.



VII. General rules in sectioning

A. Hidden lines behind the cutting plane should be omitted unless needed (Transparencies 2 and 14)

B. Sections which are too thin for effective section lining are shown solid (Transparency 17)

C. Large surfaces are often sectioned only along the edge of the part (Transparency 18)

D. If two or more sections appear on the same drawing, the cutting plane lines are labeled and the view is subtitled (Transparency 5)

E. Section lines are thin parallel lines drawn at 45° to main outline of the view (Transparencies 11 and 12)

F. In assembly sectional view, the adjacent parts section lines should be drawn at a 30°, 45°, or 60° angle to the edge of object (Transparency 10)

G. Section lines are uniformly spaced from approximate .06 to .125 (Transparencies 11 and 12)

(NOTE: Minimum space of .18 is used for microfilm.)

INFORMATION SHEET

H. Arrowheads at the ends of the cutting plane line indicate the direction in which the section is viewed (Transparency 1)

I. Where two or more thin sections are shown, a space should be left between them

(NOTE: For microfilm process see Transparency 17.)

J. When the cutting plane offsets, a line is not shown in the sectioned view to present the offset (Transparency 3)

K. When objects have one major center line, the cutting plane line may be omitted (Transparency 14)

L. Except for revolved sections, section views should be projected in the normal orthographic view (Transparencies 1, 2, 3, 4, 5, 9, and 10)

M. When dimensions on sectioned areas are unavoidable, the section lining should be omitted for the numerals or lettering (Transparency 12)

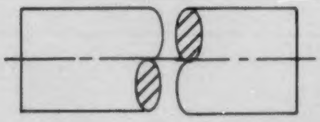
N. A center line or a visible line may be used to divide the sectioned half from the unsectioned half (Transparency 2)

O. Hidden lines may be added to unsectioned half for dimensioning (Transparency 2)

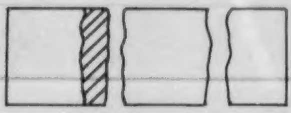
P. Visible lines behind cutting plane line should not be omitted (Transparency 13)

VIII. Types of conventional breaks

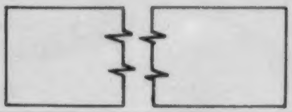
A. Round bar



B. Rectangular solid

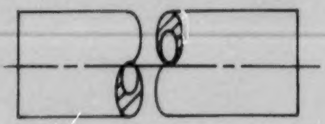


C. Long break

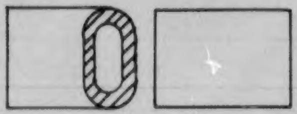


INFORMATION SHEET

D. Round tubular



E. Rectangular tubular



(NOTE: Some companies remove cross hatching from conventional breaks.)

IX. Common errors in making section lines (Transparency 19)

A. Irregular spacing

B. Varying line weight

C. Lines too thick

D. Lines short or over run visible lines

X. Use of unlined sections (Transparencies 10, 13, and 17)

A. Thin parts are made solid

B. Shafts, bolts, nuts, pins, keys, rivets, gear teeth, and similar parts should not be sectioned if axis lies in cutting plane

C. Broken-out section of shaft may be made to indicate clearness of key, keyseat, and pin

XI. Methods used to aid equal spacing of section lining

A. Visual spacing

B. Line guide

(NOTE: Scribed line on triangle may be used.)

C. Trace lines from a grid sheet

D. Measure with scale

XII. Labeling sectional views (Transparency 5)

A. More than one removed section view should be labeled with letters corresponding to the ends of the cutting plane line

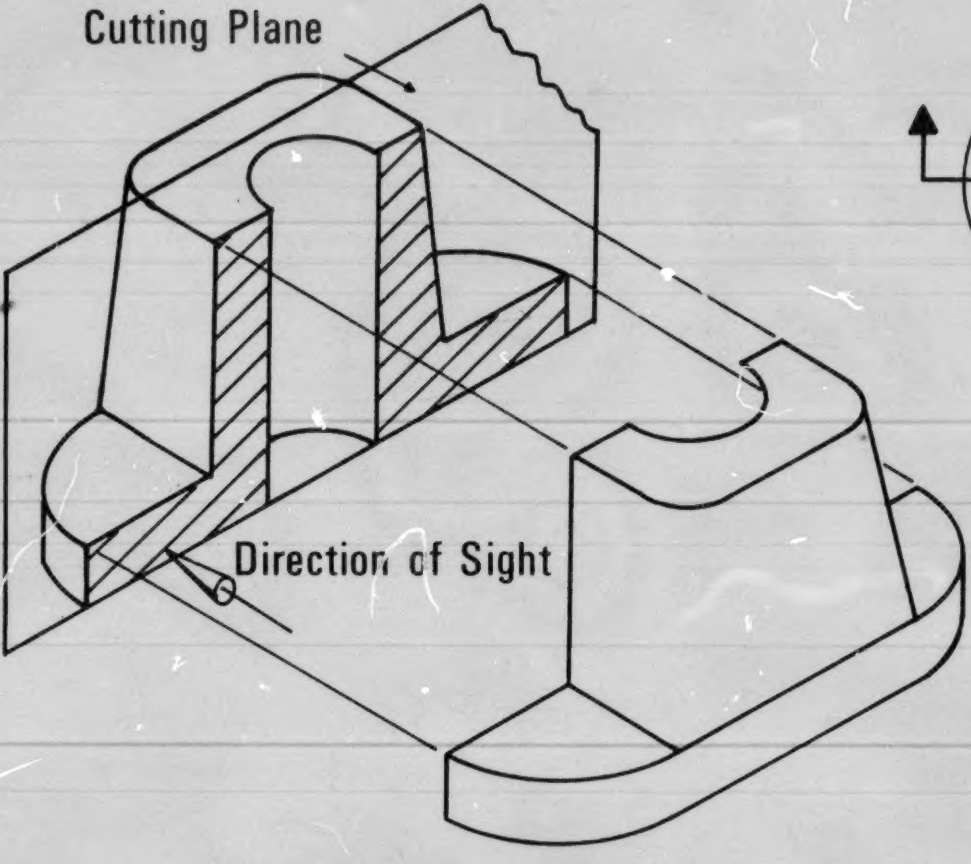
INFORMATION SHEET

B. Sectional views should be arranged in alphabetical order from left to right on the drawing

C. Section letters should be used in alphabetical order

D. Letters "I", "O", and "Q" should not be used

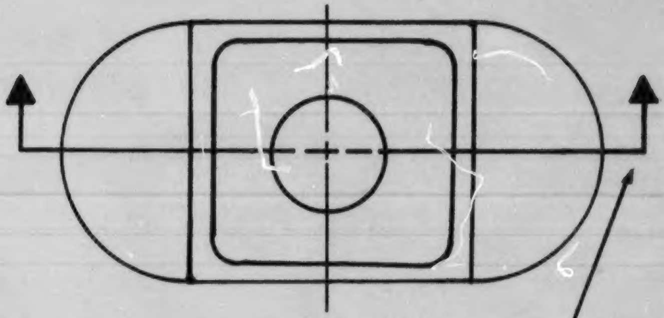
Full Section



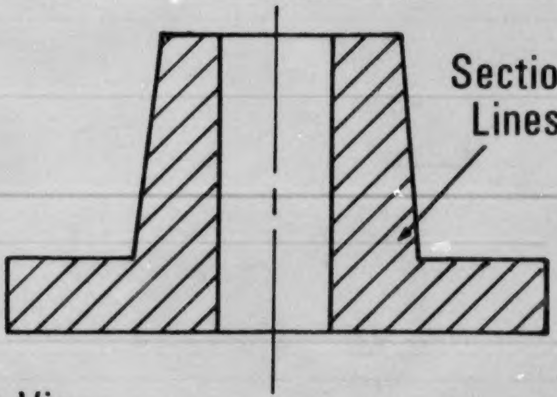
Cutting Plane

Direction of Sight

Top View



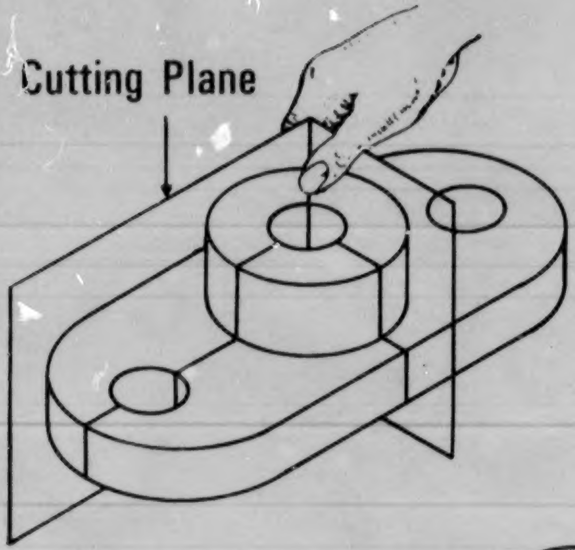
Edge View of Cutting Plane



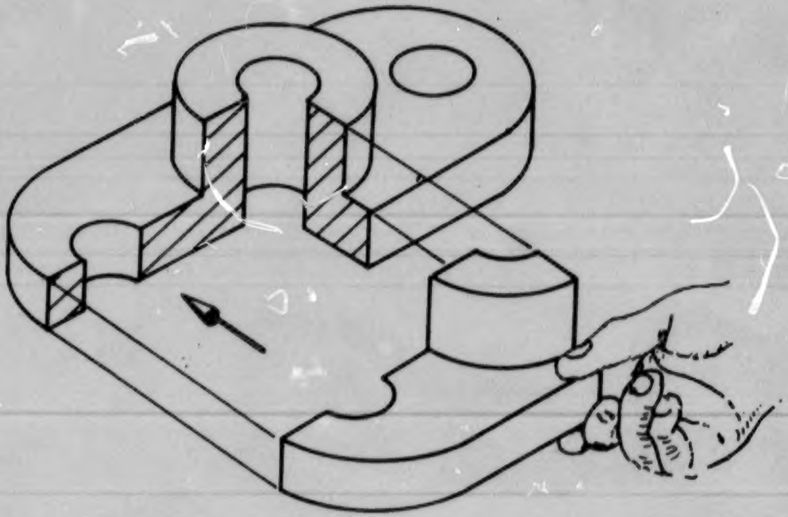
Section Lines

Front View

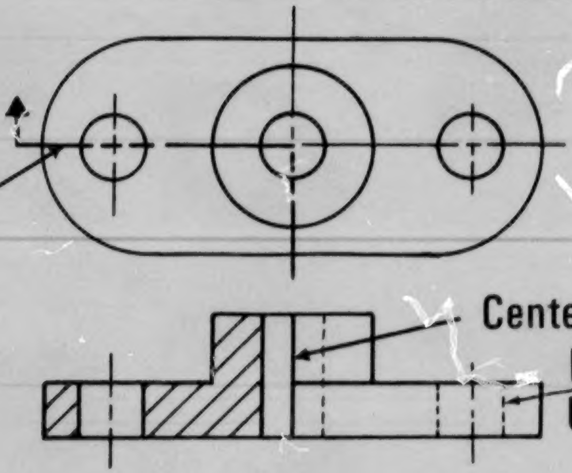
Half Section



Cutting Plane



Remove One Quarter

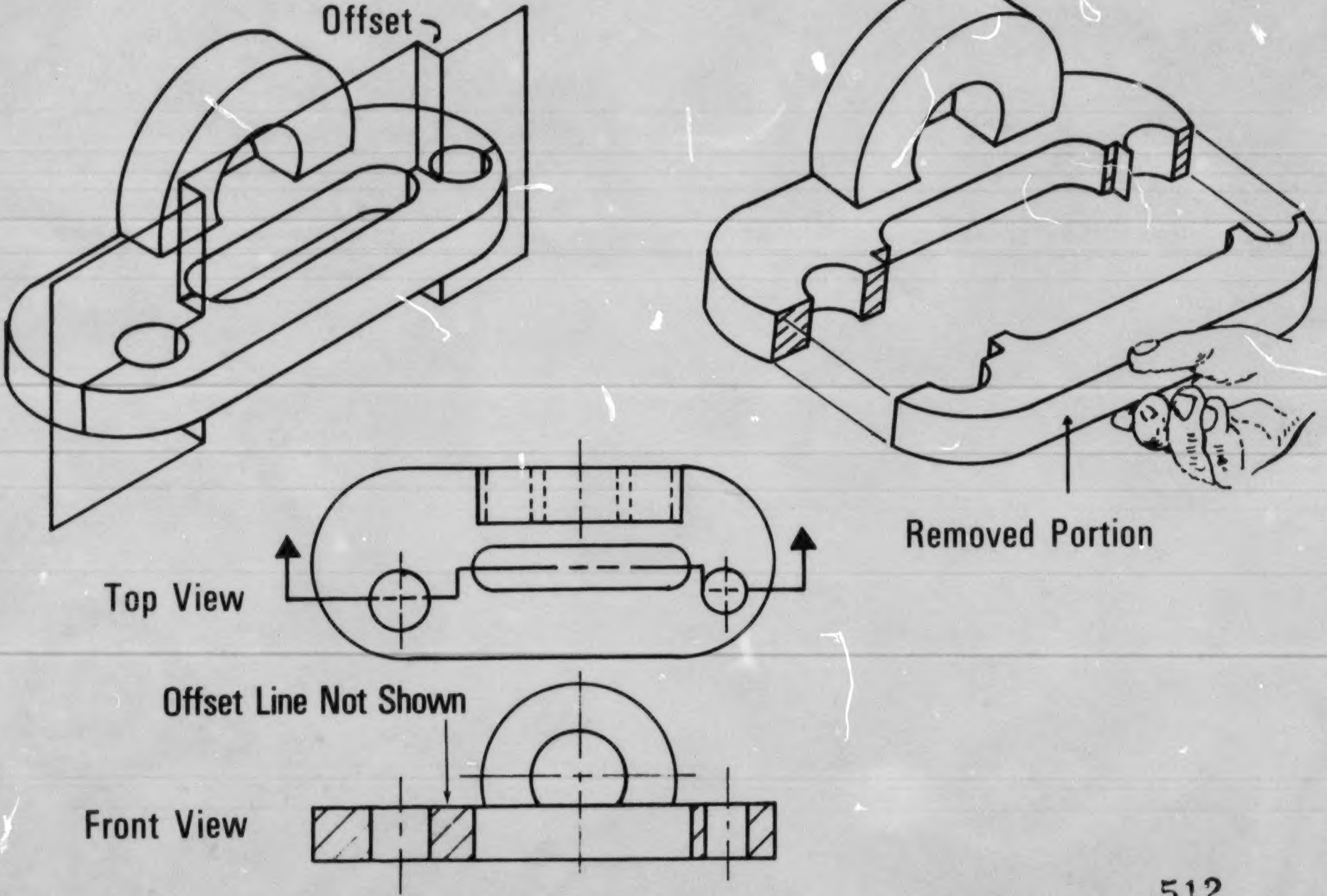


Edge View of Cutting Plane

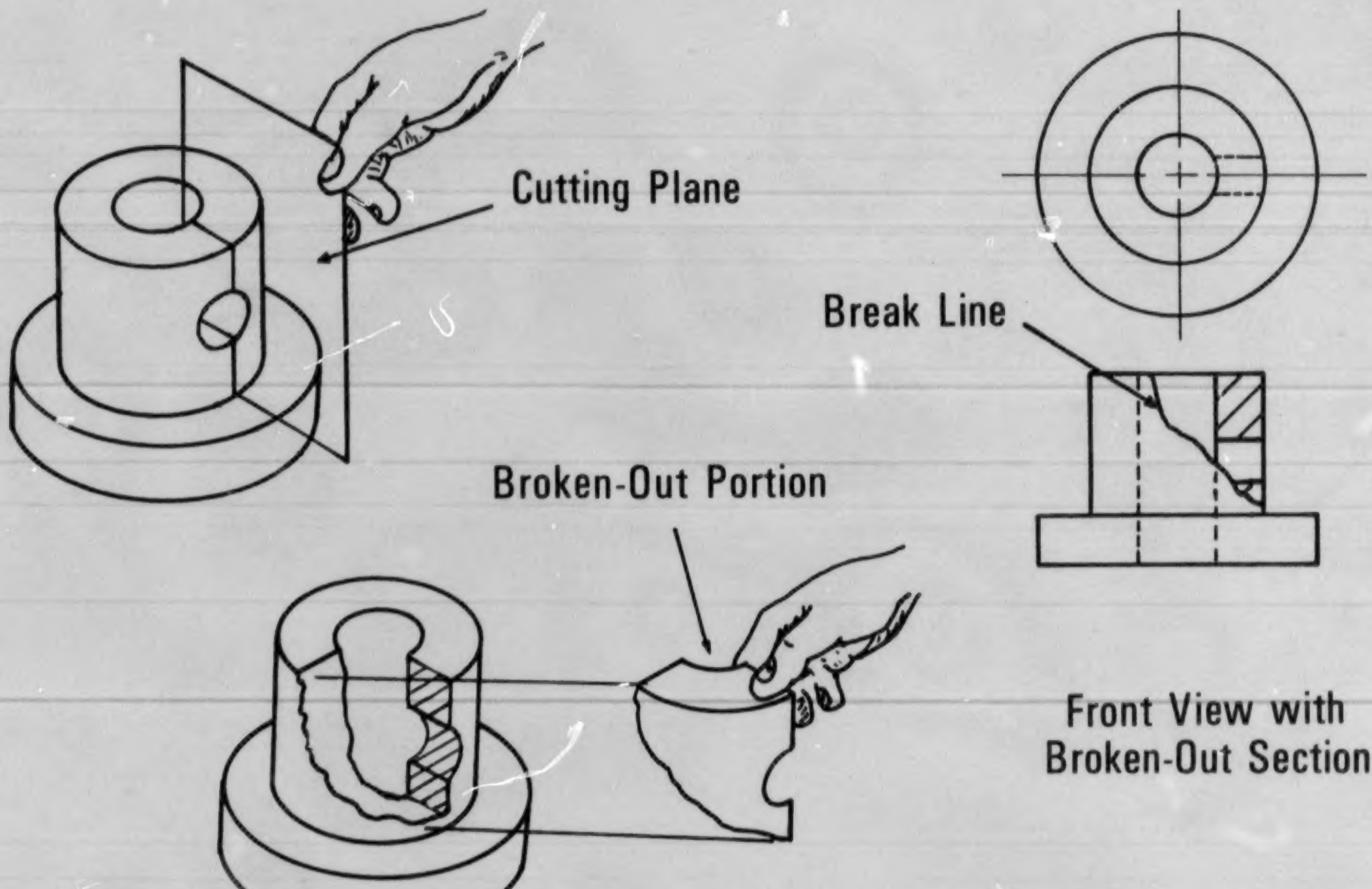
Center Line or Visible Line

Hidden Lines Omitted Unless Used for Dimensioning

Offset Section


Offset
Removed Portion
Top View
Offset Line Not Shown
Front View

Broken-Out Section



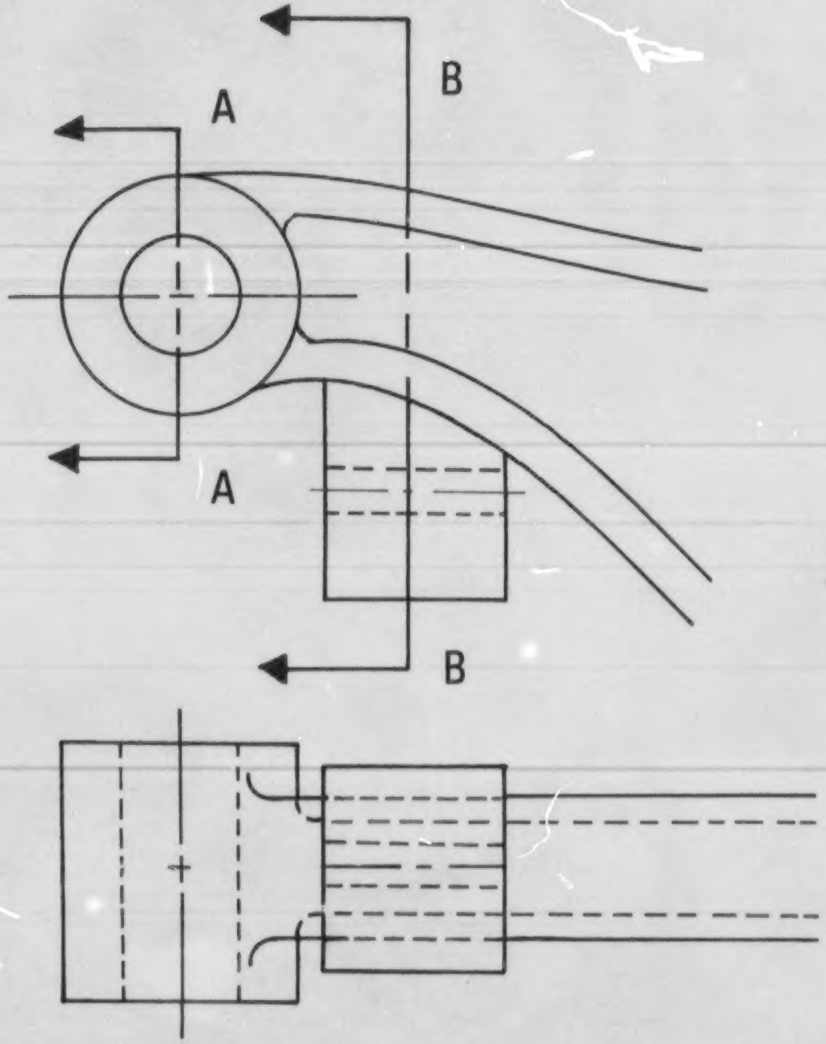
Cutting Plane

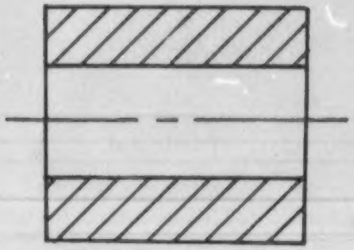
Break Line

Broken-Out Portion

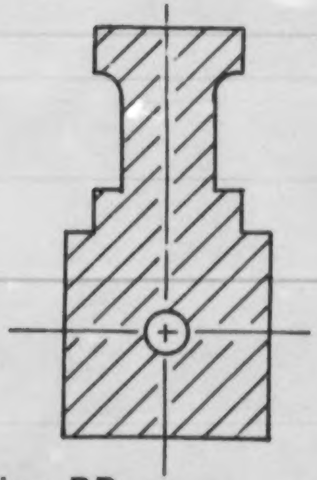
Front View with
Broken-Out Section

Removed Section





Section AA

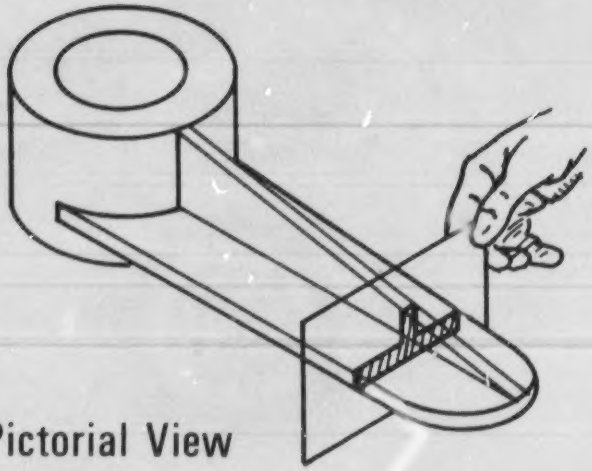


Section BB

TM 5

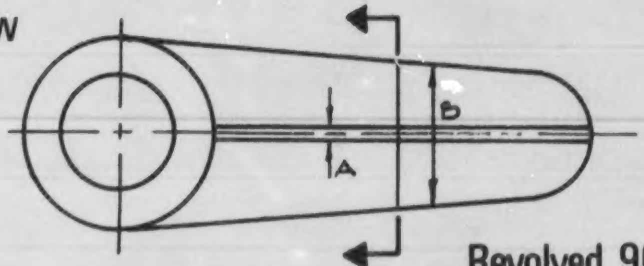
D II - 597

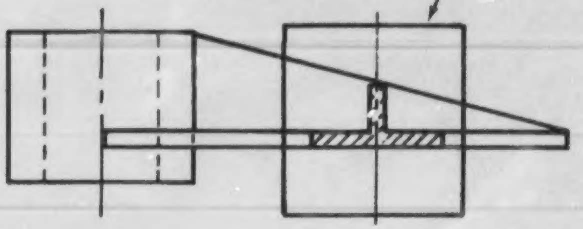
Revolved Section



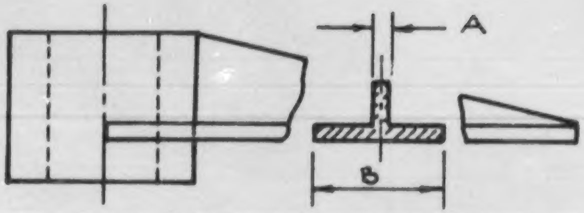
Pictorial View

Top View

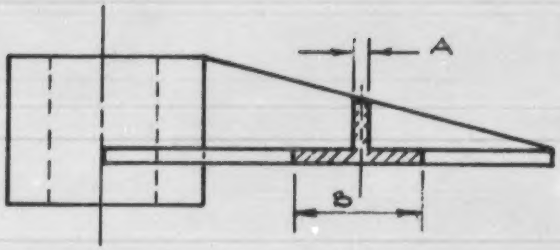



Revolved 90°

Front View

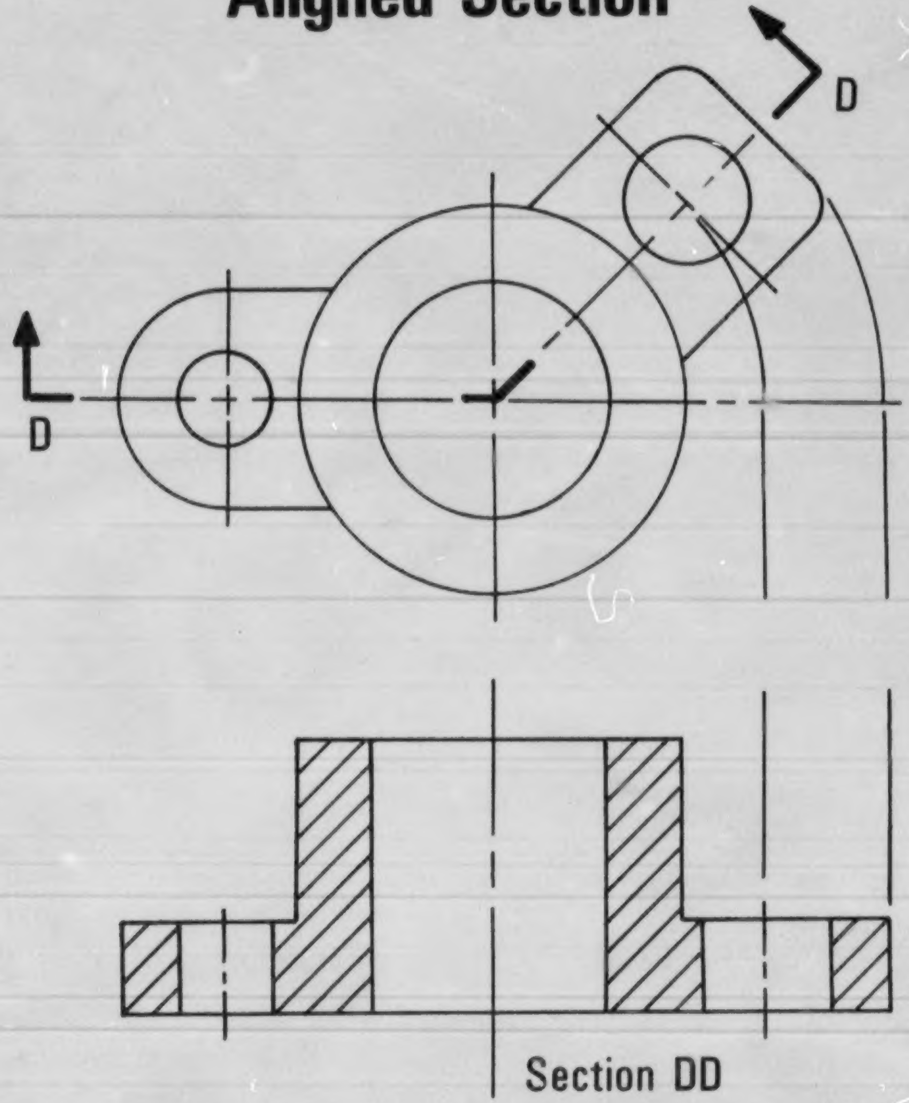


Broken Around Section



Section in View

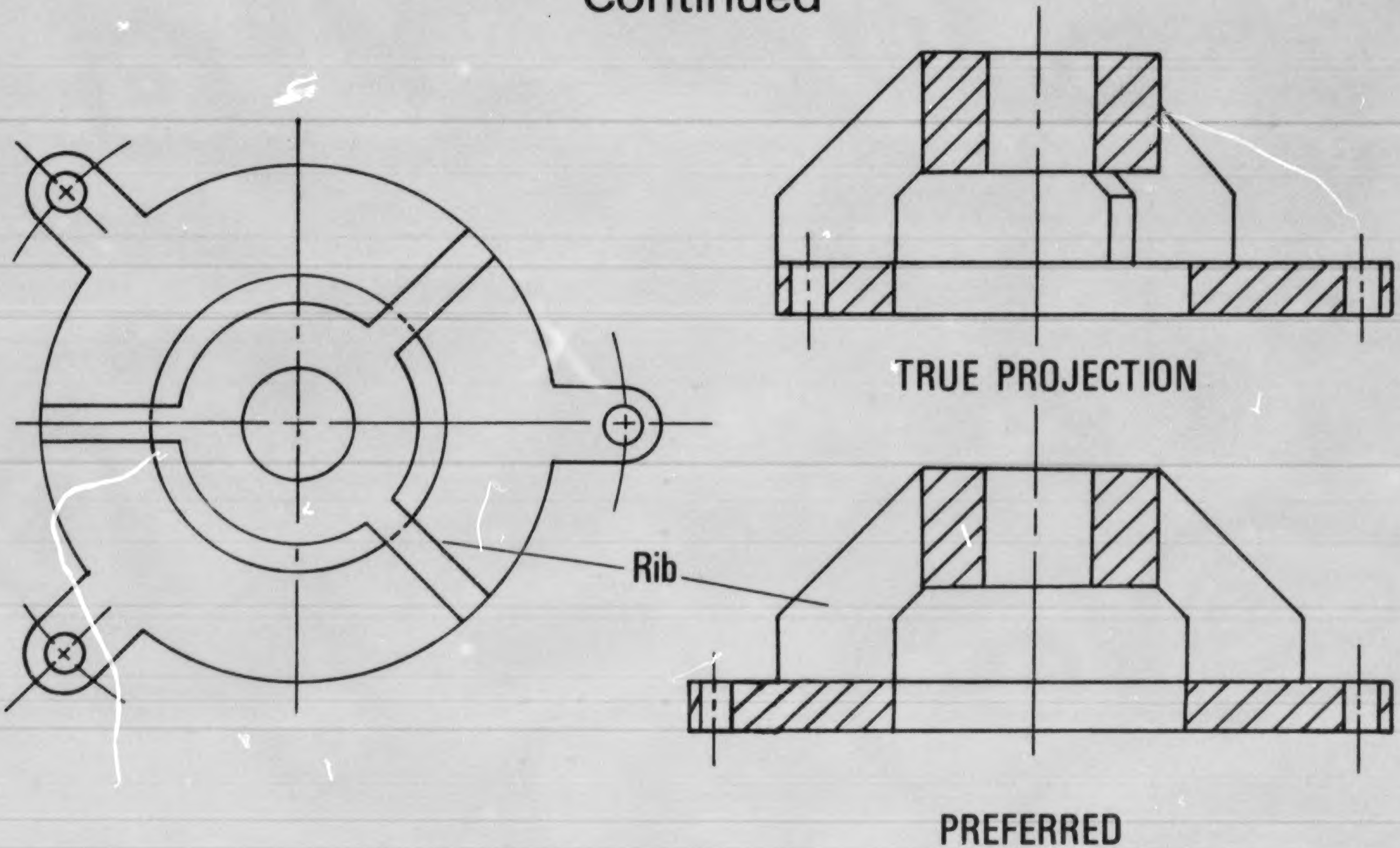
Aligned Section



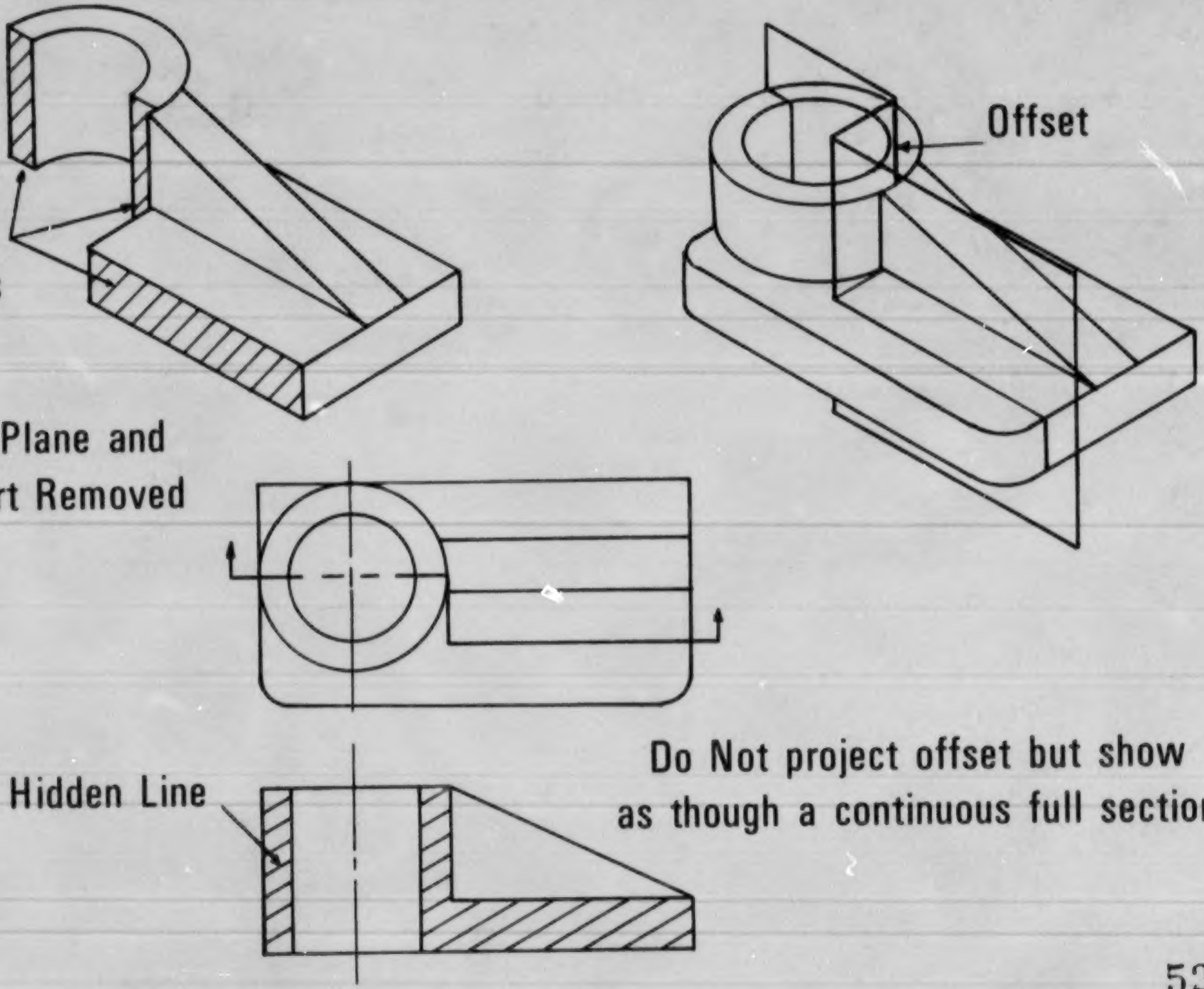
Section DD

Aligned Section

Continued


Rib
TRUE PROJECTION
PREFERRED

Rib Section



The Cut Surfaces

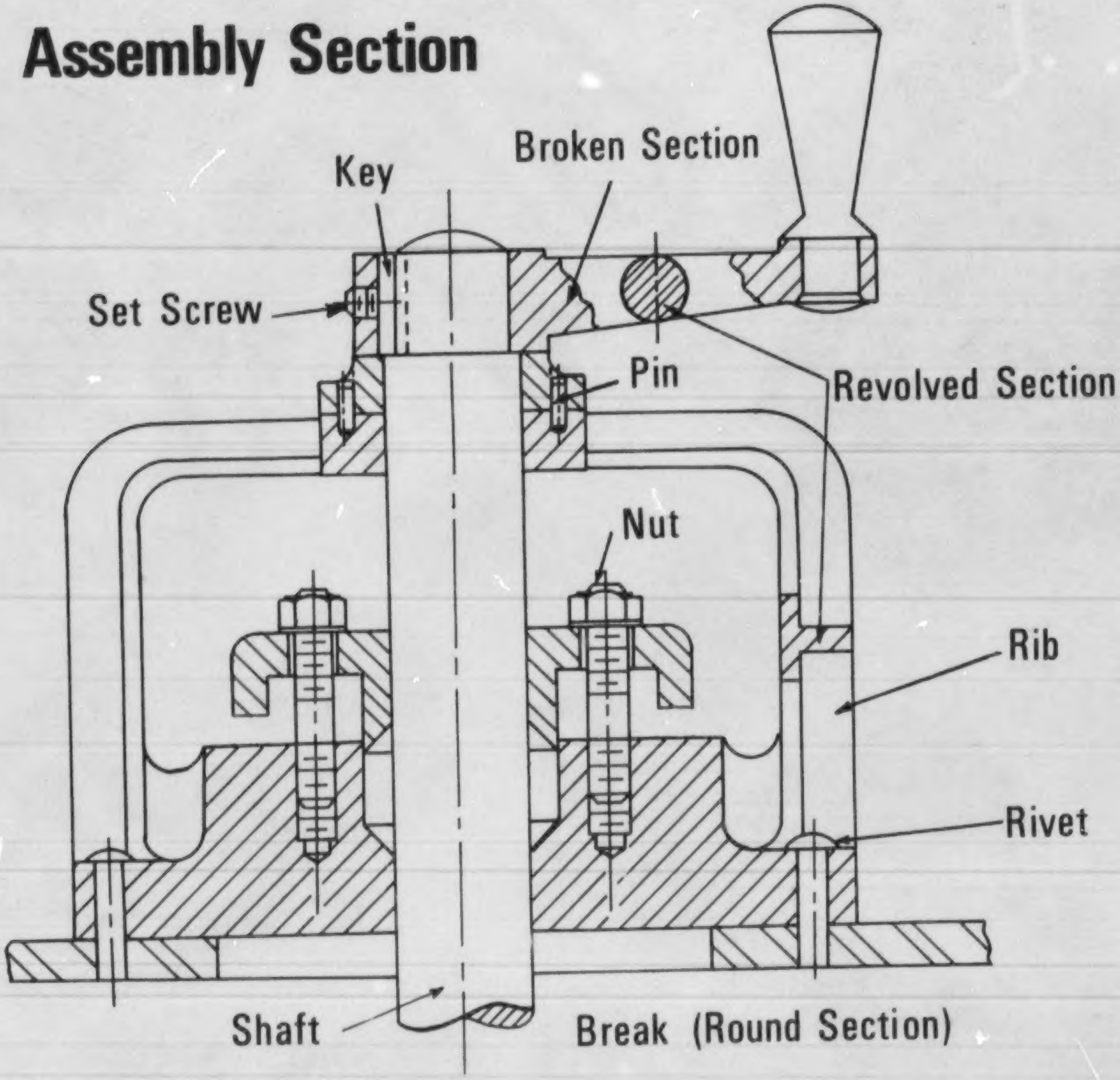
Offset

Cutting Plane and Front Part Removed

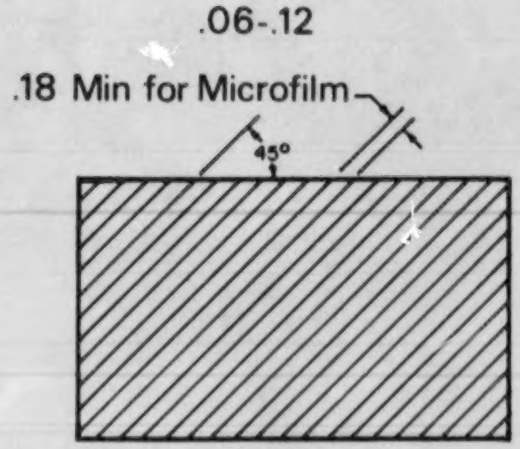
Omit Hidden Line

Do Not project offset but show as though a continuous full section.

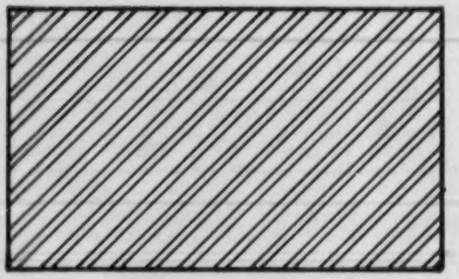
Assembly Section


Broken Section
Key
Set Screw
Pin
Revolved Section
Nut
Rib
Rivet
Shaft
Break (Round Section)

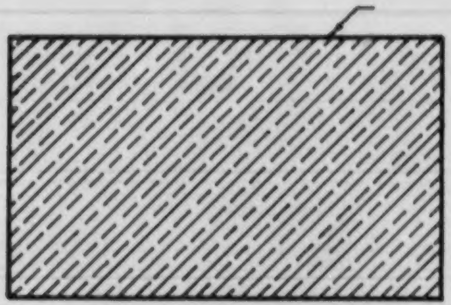
Material Symbols in Section


.06-.12
.18 Min for Microfilm
45°

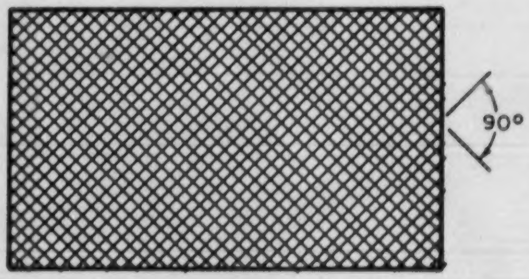
Cast Iron



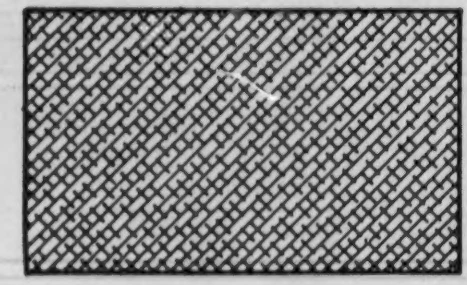
Steel



Brass-Bronze-Copper

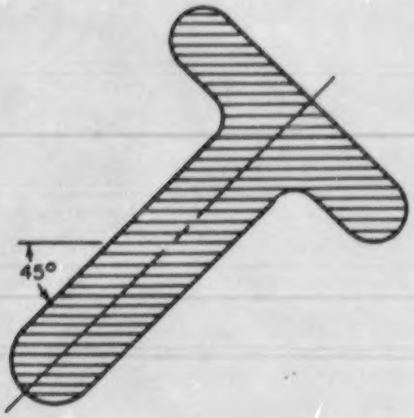


Zinc-Lead-Babbitt

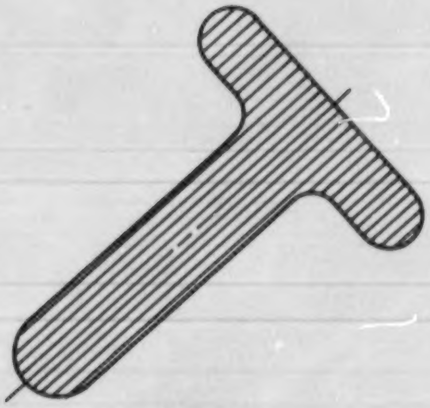


Aluminum-Magnesium

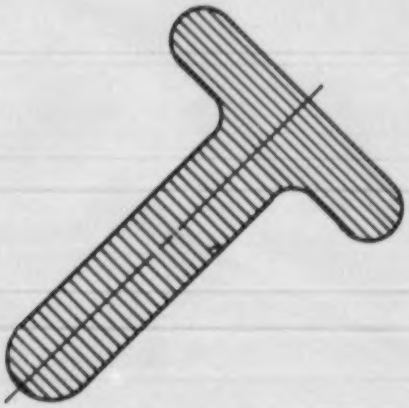
Direction of Section Lines



Correct

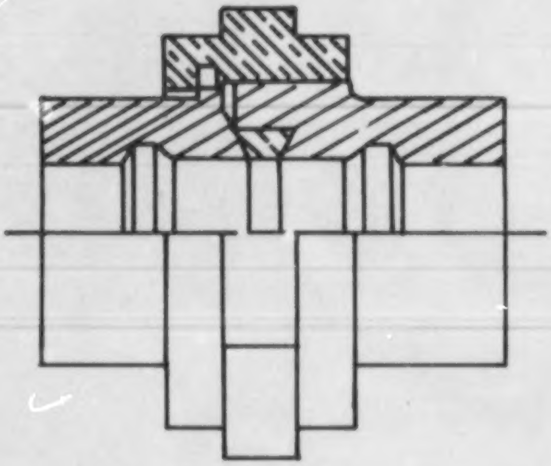


Incorrect

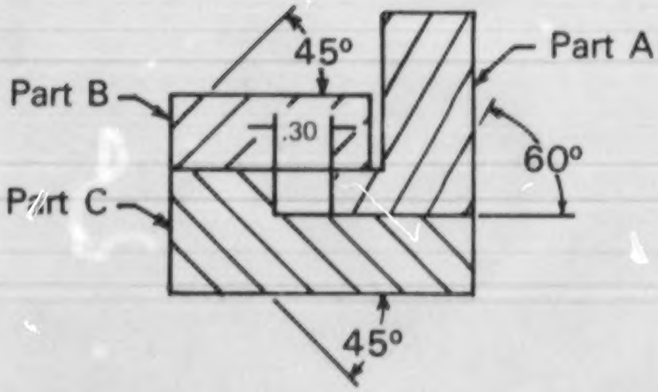


Incorrect

Materials in Assembly Section

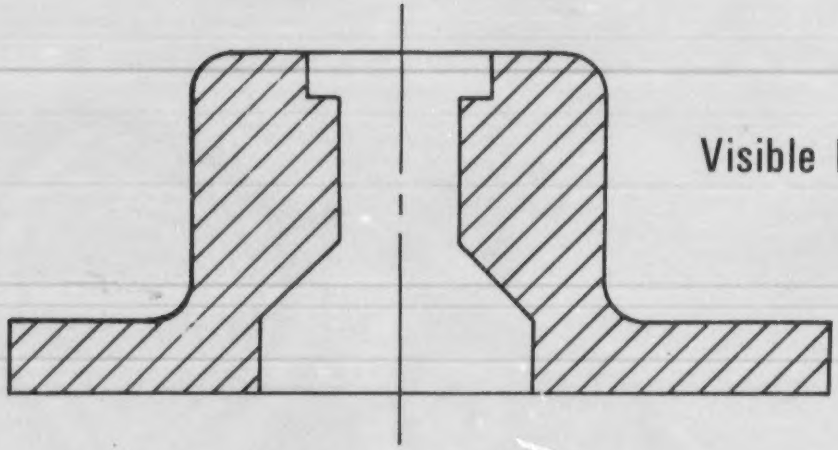


Materials in Section


45°
Part A
Part B
.30
60°
Part C
45°

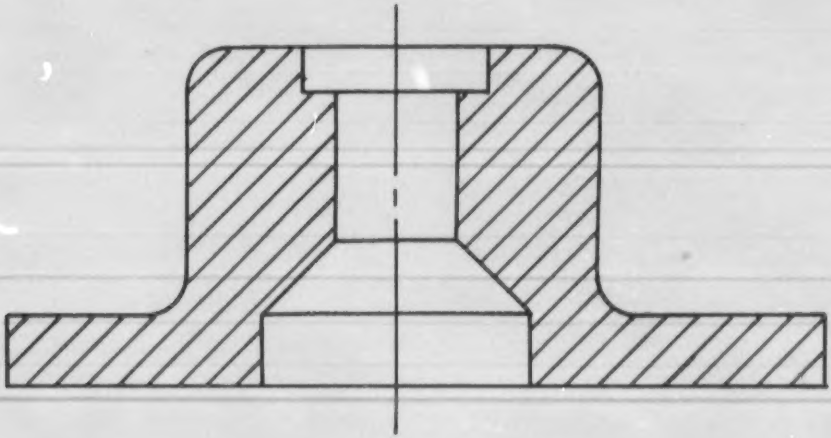
Adjacent Parts

Visible Lines



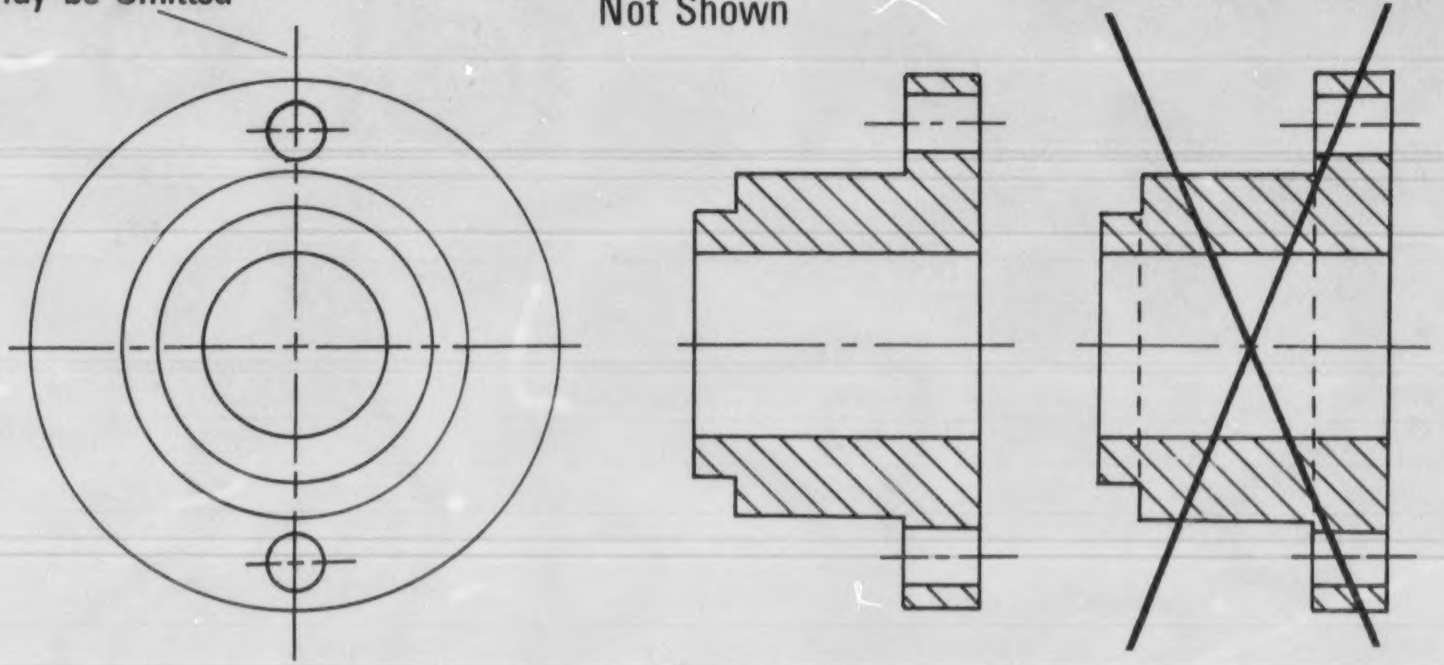
Visible Lines Omitted

INCORRECT



CORRECT

Hidden Lines



Cutting Plane Line May be Omitted

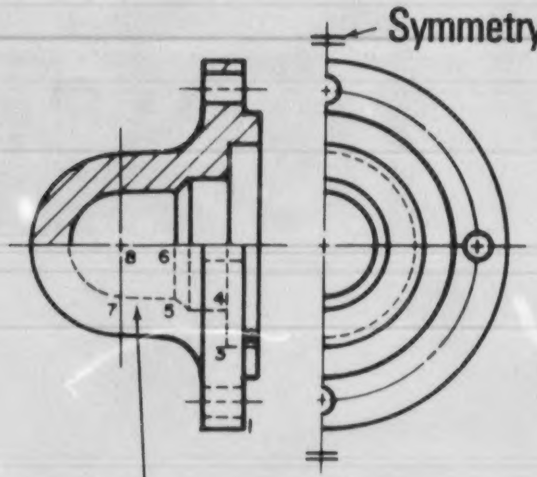
Hidden Lines Not Shown

Hidden Lines

GOOD

NOT GOOD

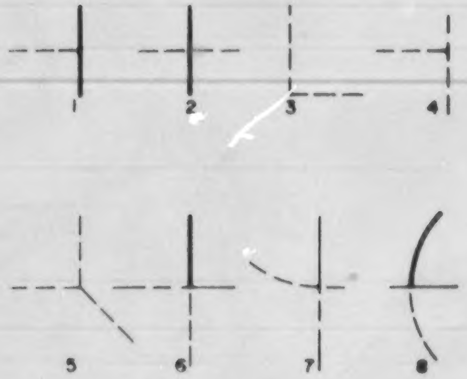
Hidden and Symmetry Line Application



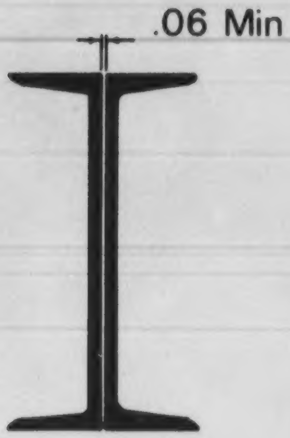
Symmetry Line

Hidden Lines Omitted unless Used for Dimensioning

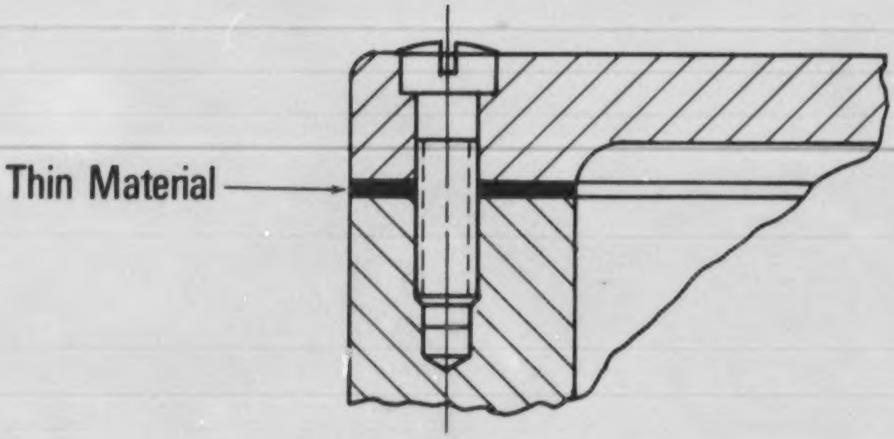
Enlarged Details



Thin Sections

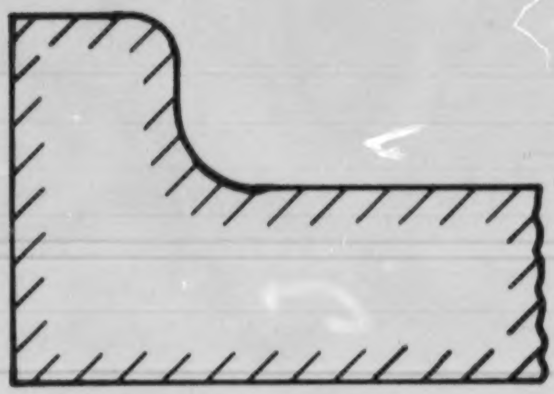


Structural Shapes

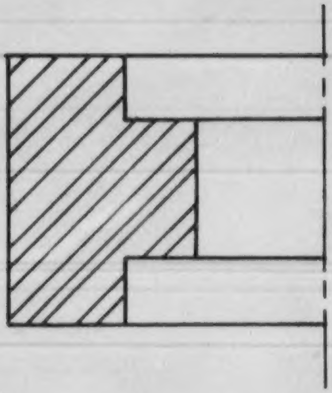

Thin Material

Gasket

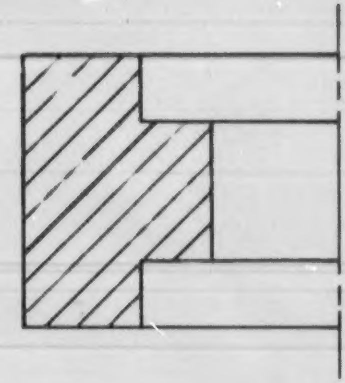
Outline Section



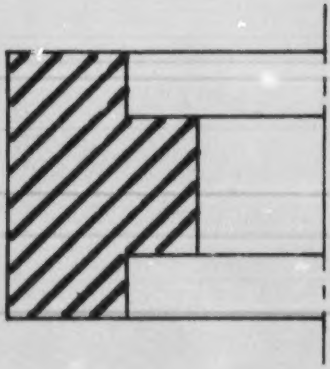
Errors in Making Section Lines



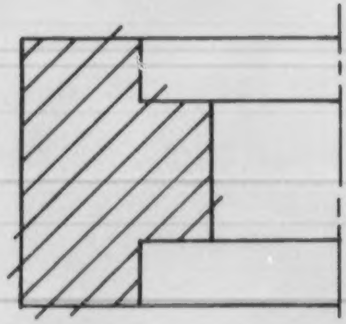
Uneven Spacing



Uneven Line Weight



Lines Too Thick



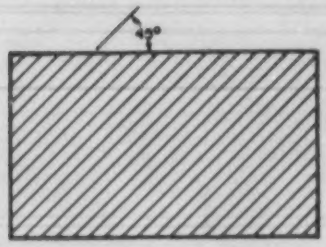
Overrun Lines

SECTIONAL VIEWS
UNIT VII

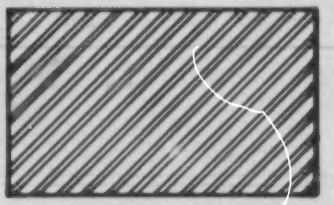
ASSIGNMENT SHEET #1--CONSTRUCT VARIOUS MATERIAL SYMBOLS IN SECTION

Premise: The quality of any drawing reproduction depends on the quality of line work. Open space between two adjacent parallel lines should be thin, dark, and consistent. Light section lines tend to "fade out." A minimum of section lining is sufficient to clarify a sectional view.

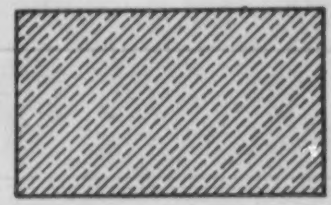
Directions: Duplicate the given symbols for materials in section in the spaces provided below. Label under each space in 1/8" letters the name of the material.



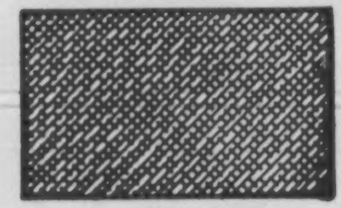
Cast Iron



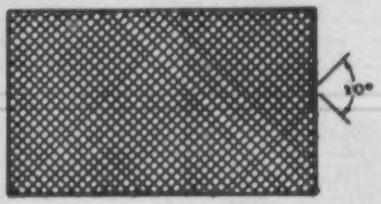
Steel



Brass-Bronze-Copper



Aluminum-Magnesium



Zinc-Lead-Babbitt

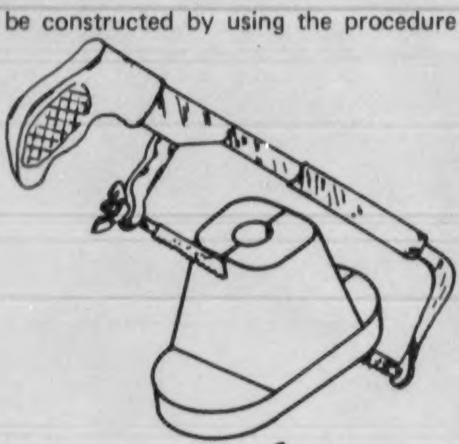
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #2--CONSTRUCT A FULL SECTION OF AN OBJECT

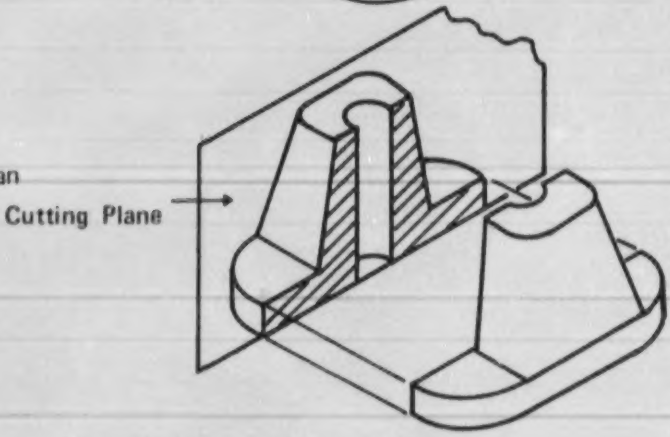
Premise: A full section view of an object can be constructed by using the procedure in the following example.

Example:

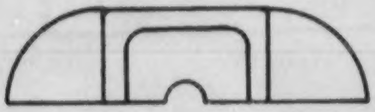
1. Imagine cutting an object all the way across with a hacksaw



2. Think of the saw cut as an imaginary cutting plane



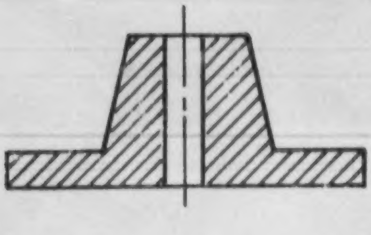
TOP VIEW



3. With the front half removed, visualize what the front view would look like

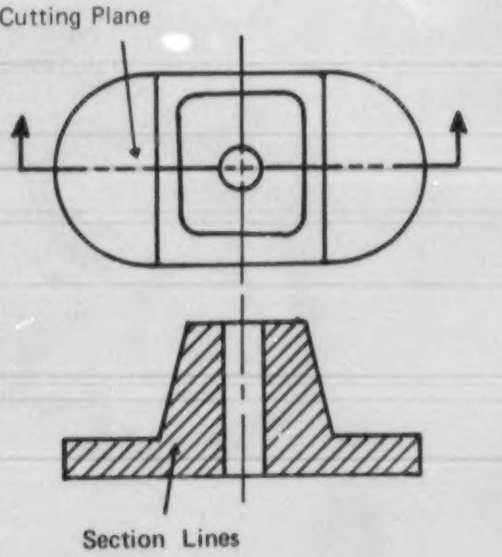
(NOTE: This is a full section.)

FRONT VIEW

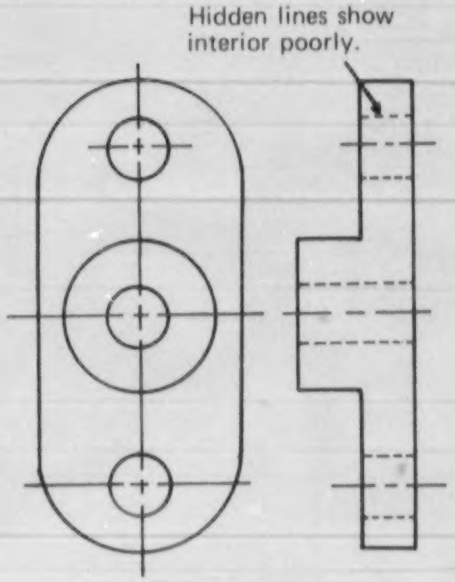


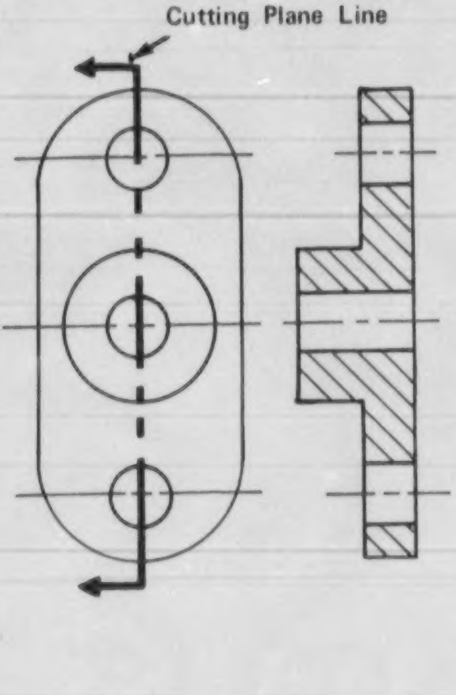
ASSIGNMENT SHEET #2

4. On a drawing you would show the complete top view and its cutting plane line; the area actually cut by the hacksaw would be represented with section lines


Cutting Plane
Section Lines

5. On an actual drawing, the two views would be drawn lightly as in orthographic projection with hidden lines, etc; then the drafter would visualize the internal features of the object and draw that view in section omitting hidden lines

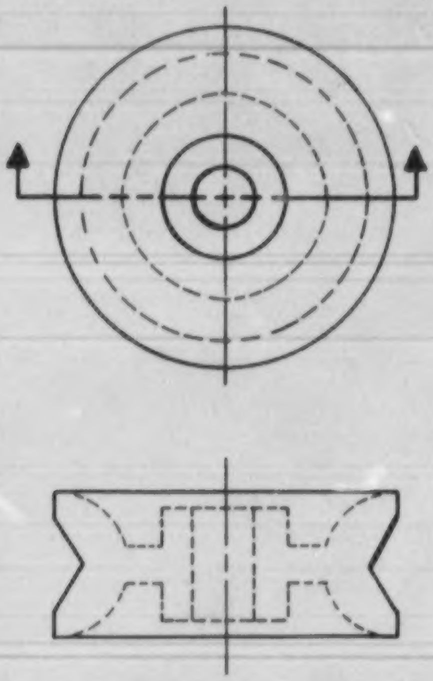

Hidden lines show interior poorly.


Cutting Plane Line

ASSIGNMENT SHEET #2

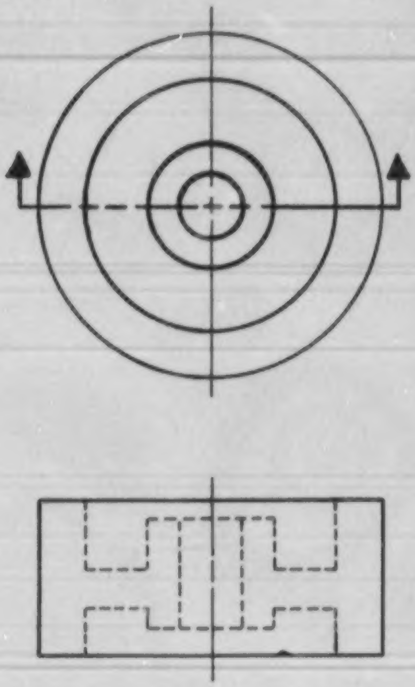
Directions: Change the front views of objects below to full section views.

Problem A:



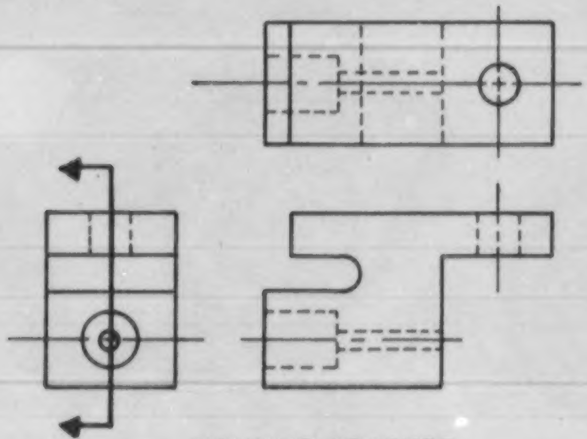
V PULLEY

Problem B:



BELT DRIVE

Problem C:

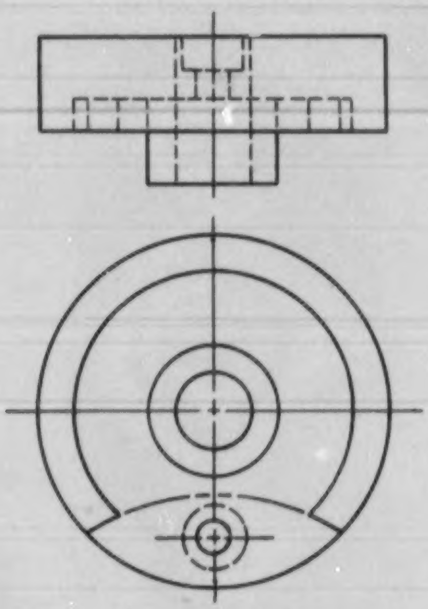


HOLDING BRACKET

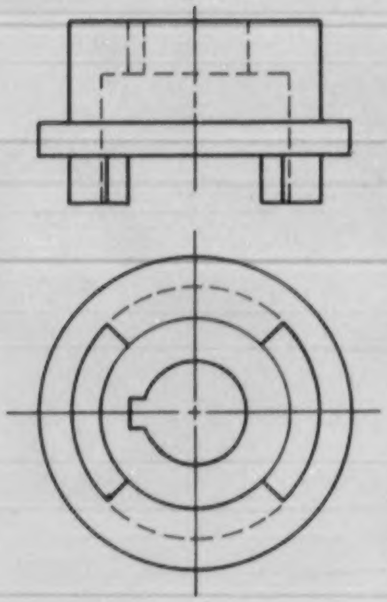
ASSIGNMENT SHEET #2

Directions: Complete the right side views of the following problems to full section views.

Problem D:



Problem E:



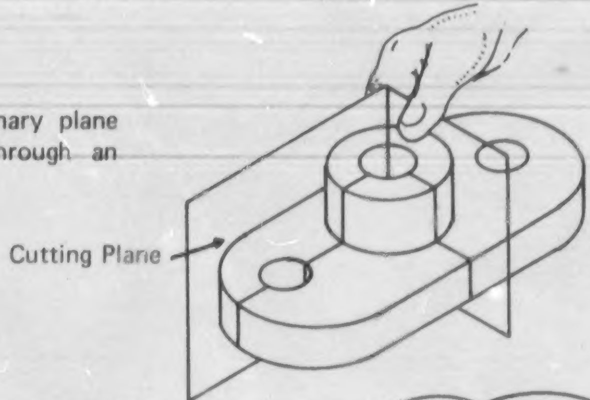
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #3--CONSTRUCT A HALF SECTION OF AN OBJECT

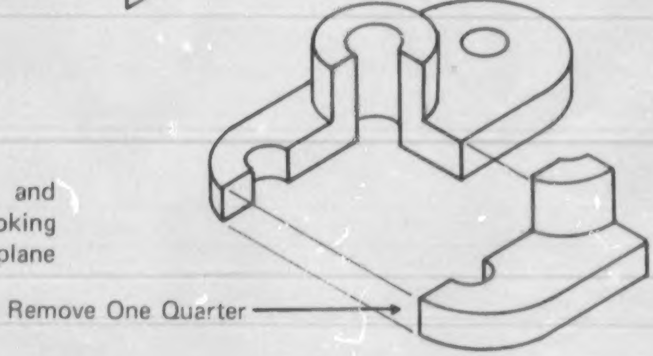
Premise: A half section view of an object can be constructed by using the procedure in the following example.

Example:

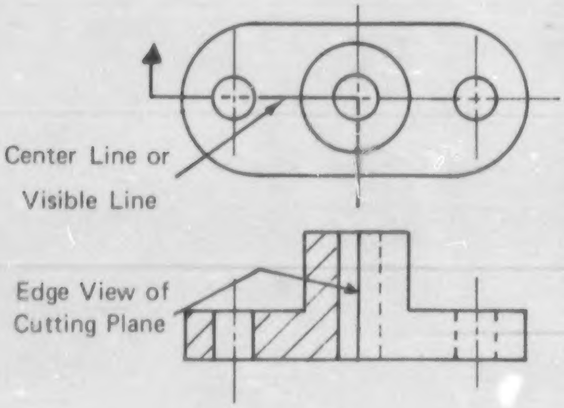
1. Think of an imaginary plane cutting halfway through an object


Cutting Plane

2. Remove that section and assume a line of sight looking into the area cut by the plane


Remove One Quarter

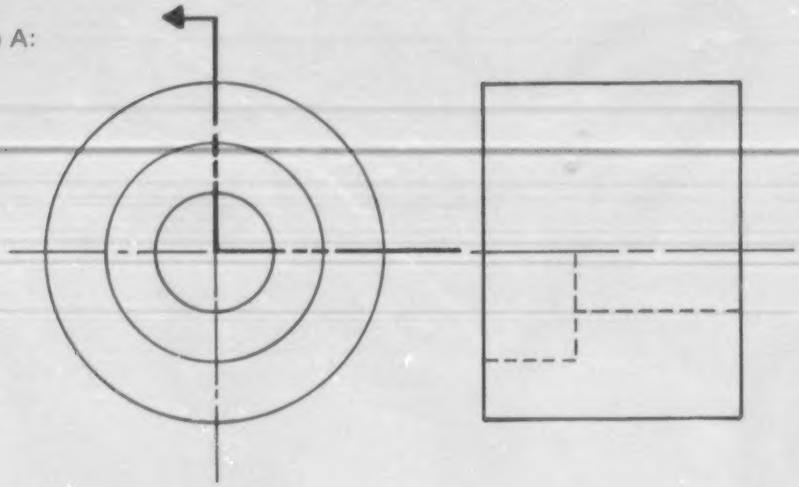
3. Construct top view with a cutting plane line that passes halfway through the object; project lines to front view and determine areas to be sectioned


Center Line or
Visible Line
Edge View of
Cutting Plane

ASSIGNMENT SHEET #3

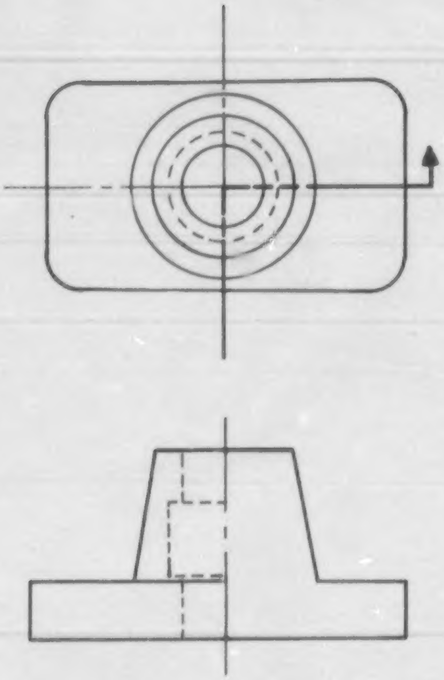
Directions: Construct section lines in the part of the view behind the cutting plane line.

Problem A:



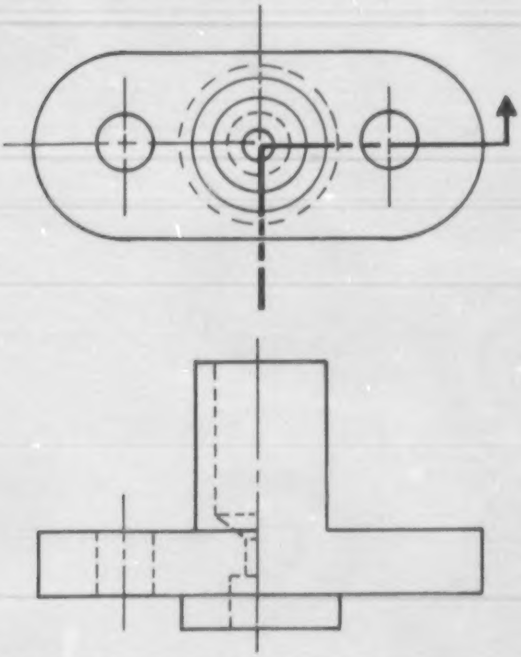
BUSHING

Problem B:



BRACKET BASE

Problem C:

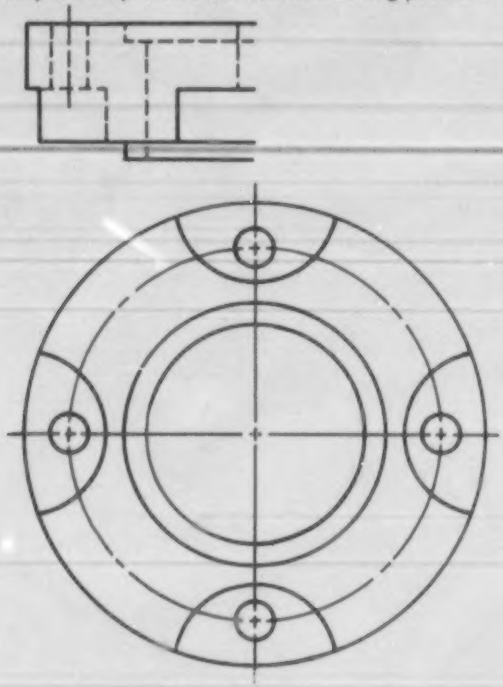


SHAFT SUPPORT

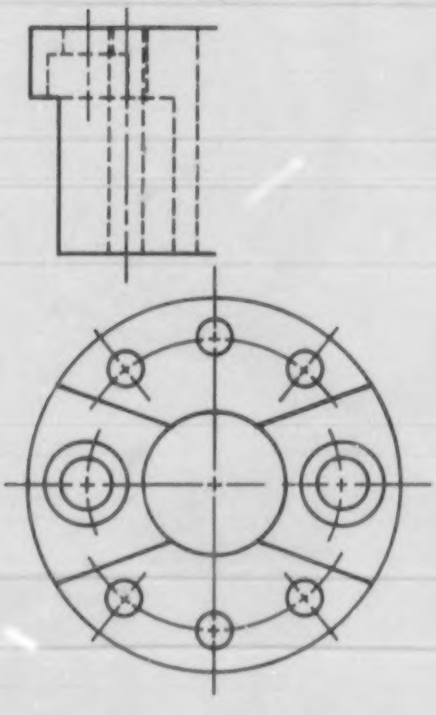
ASSIGNMENT SHEET #3

Directions: Complete top views for the following problems to half sections.

Problem D:



Problem E:



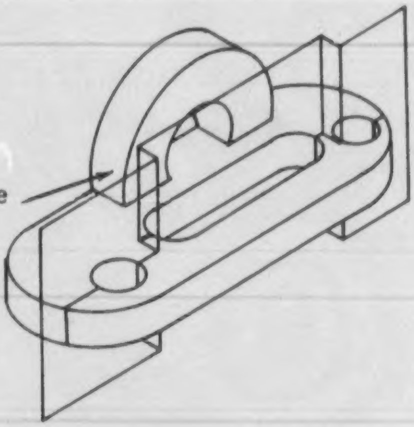
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #4--CONSTRUCT AN OFFSET SECTION OF AN OBJECT

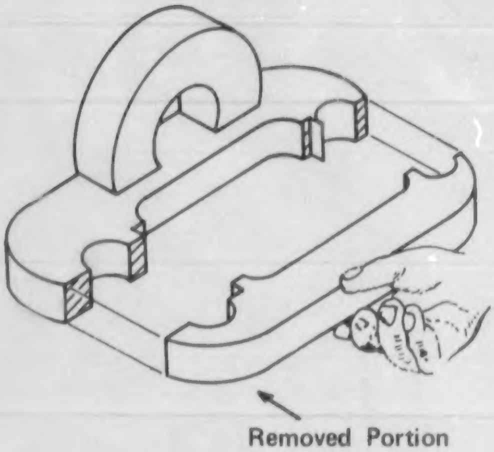
Premise: An offset section of an object can be constructed by using the procedure in the following example.

Example:

1. Decide which features about this object are not in a common line but should be shown in section



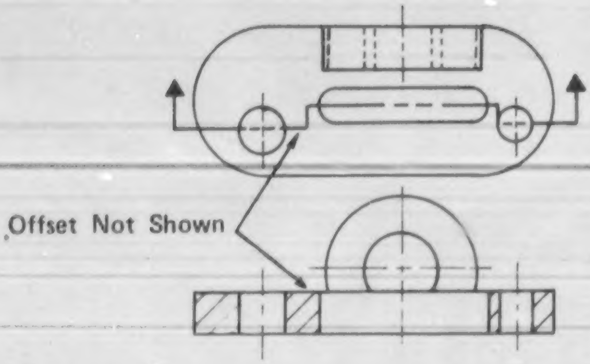
2. Remove the portion in front and look into the object



ASSIGNMENT SHEET #4

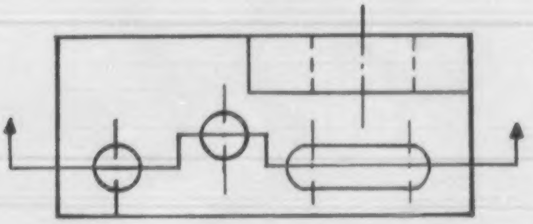
3. A drawing of the top view would show the offset of the cutting plane; the front section view would show the object as if the slot and holes were all on the same center line

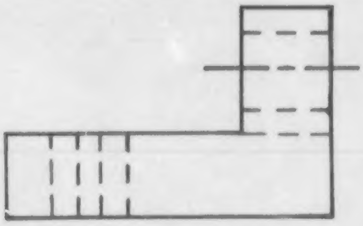
   (NOTE: The offsets in the cutting plane are not shown with a line in the front section.)



Directions: Construct the front view in section.

Problem A:

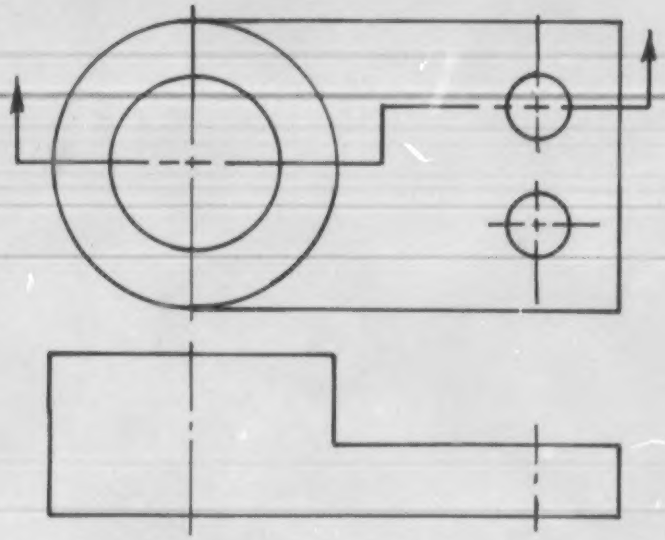




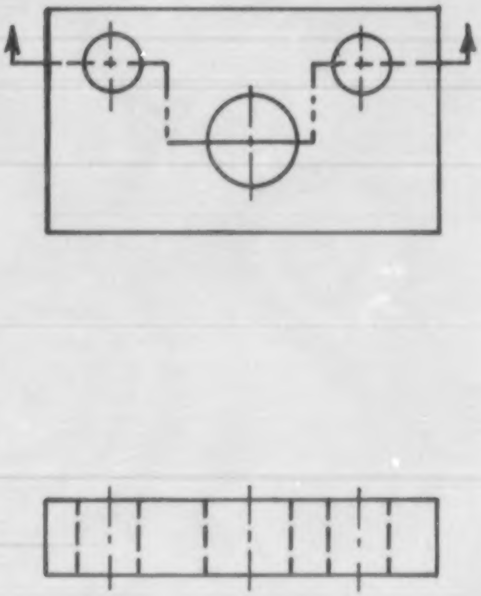
ASSIGNMENT SHEET #4

Directions: Complete the front views to offset sections for the following problems.

Problem B:



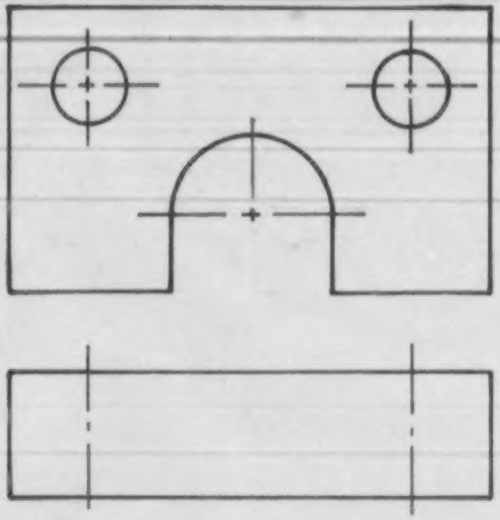
Problem C:



ASSIGNMENT SHEET #4

Directions: Construct the cutting plane in top view and complete the front view to an offset section.

Problem D:



SECTIONAL VIEWS
UNIT VII

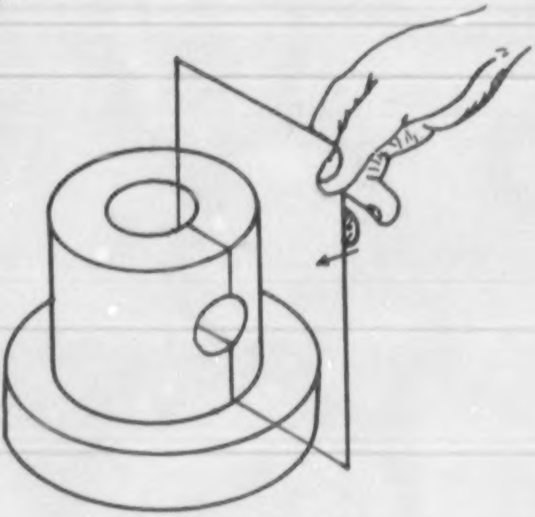
ASSIGNMENT SHEET #5--CONSTRUCT A BROKEN-OUT SECTION OF AN OBJECT

Premise: A broken-out section needs to be used only when a portion of the whole object needs to be sectioned. A broken-out section of an object can be constructed by using the procedure in the following example.

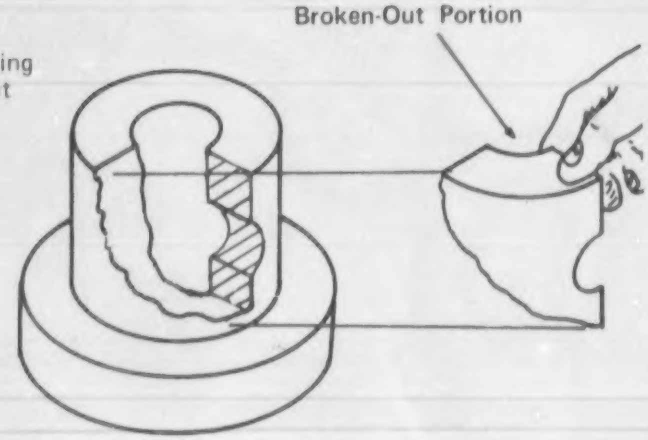
Example:

1. Pass an imaginary cutting plane through the area to be sectioned

   (NOTE: Cutting plane line is not shown on drawing.)

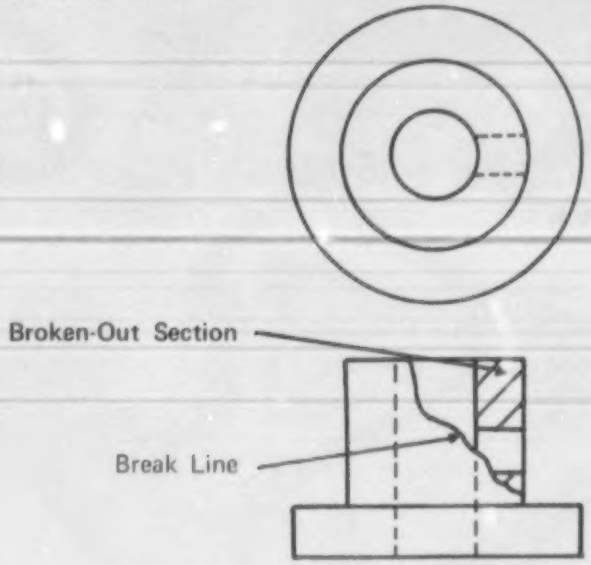


2. Remove the portion by breaking it off and visually lifting it out of position



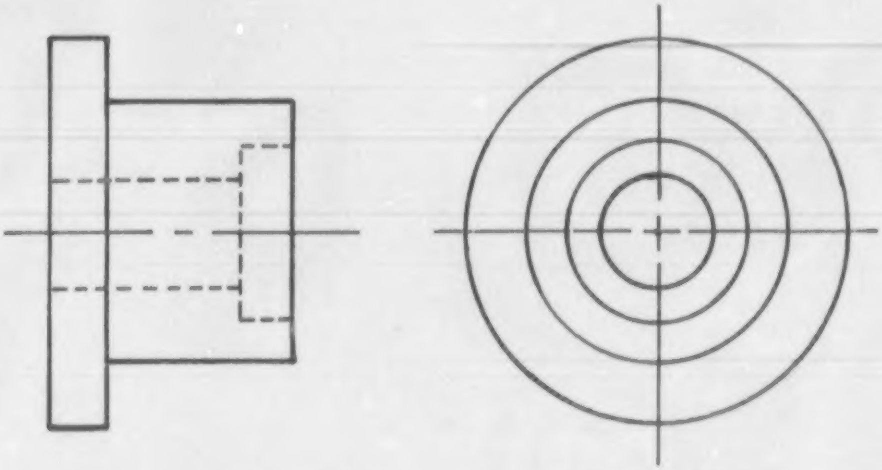
ASSIGNMENT SHEET #5

3. On a drawing, the area cut by the plane would appear in section and the broken area would be represented with a short break line; draw the top and front view lightly, then remove the portion that needs to be sectioned



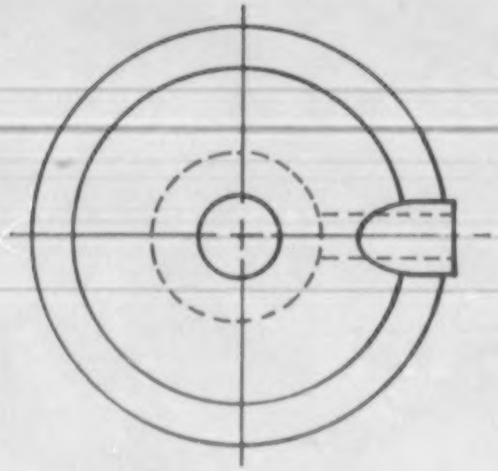
Directions: Construct broken-out sections in front view for the following problems.

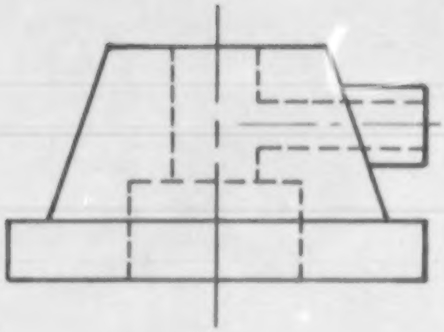
Problem A: Bronze material



ASSIGNMENT SHEET #5

Problem B: Cast iron material

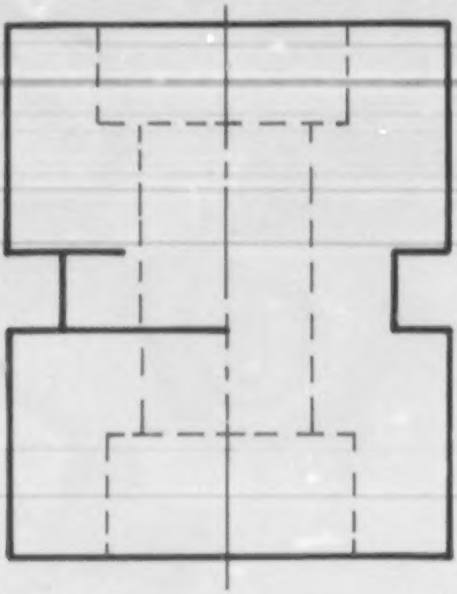




ASSIGNMENT SHEET #5

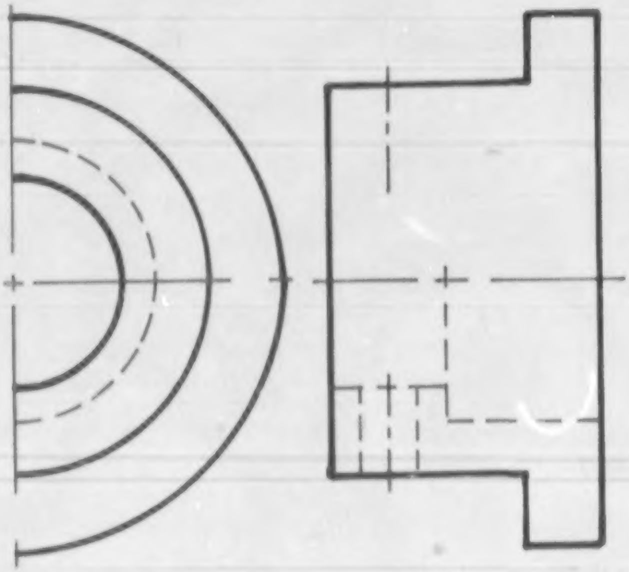
Directions: Construct a broken-out section of the view below.

Problem C: Material as described by instructor



Directions: Construct a broken-out section in right side view.

Problem D: Material as described by instructor



SECTIONAL VIEWS
UNIT VII

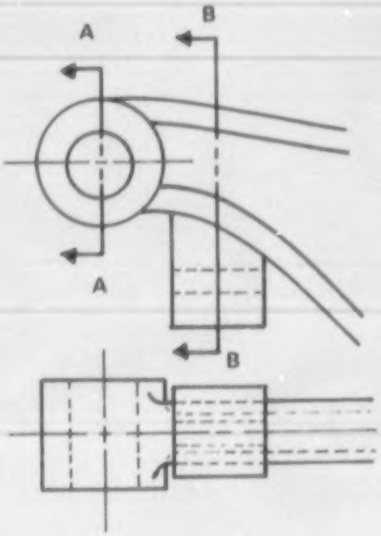
ASSIGNMENT SHEET #6--CONSTRUCT A REMOVED SECTION OF AN OBJECT

Premise: A removed section is used to illustrate an area separate from its view by passing an imaginary plane through an area and then drawing it in section and labeling it to correspond to its cutting plane. Removed sections are often used when several sections are taken through one view of an object. A removed section of an object can be constructed by using the procedure in the following example.

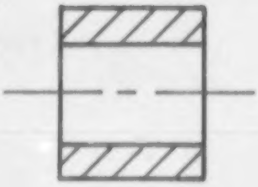
Example:

1. Determine the area to be sectioned and pass a cutting plane line through it

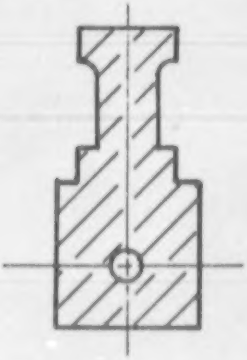
   (NOTE: Label the cutting plane lines A-A, B-B, etc.)



2. Construct the sections indicated by the cutting plane lines on any area of the drawing where space is available but keep axis of section the same as the view it was taken from, if possible



SECTION AA

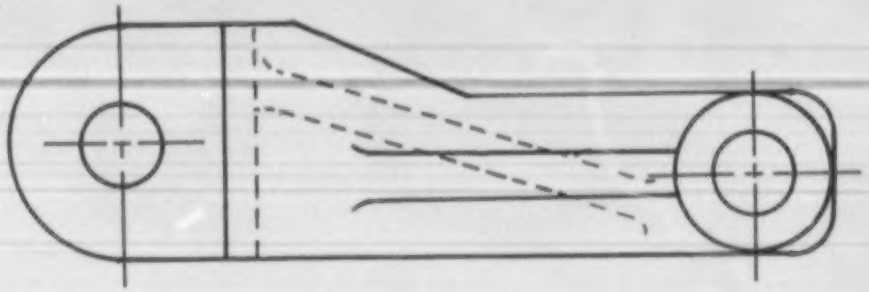


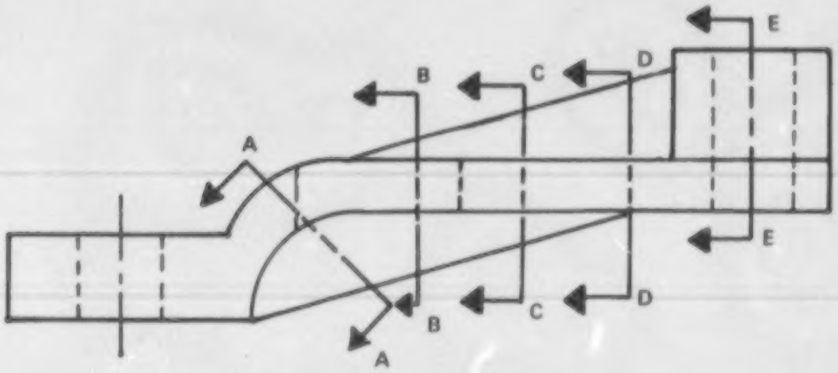
SECTION BB

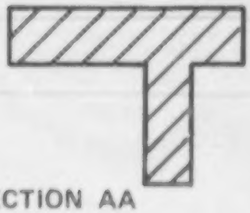
ASSIGNMENT SHEET #6

Directions: Pictured below are two views of an object with a series of sections cut through it. Pictured beside it are three of its sections. Complete the other two sections D-D and E-E. Type of material will be assigned by instructor.

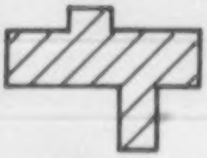
Problem A:



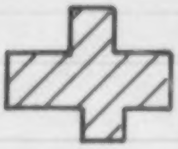




SECTION AA



SECTION BB



SECTION CC

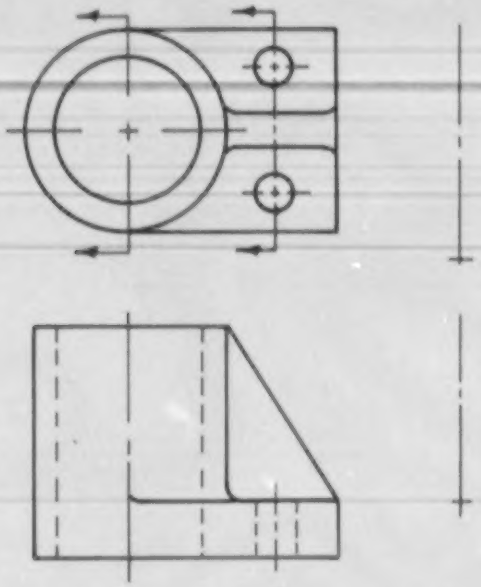
SECTION DD

SECTION EE

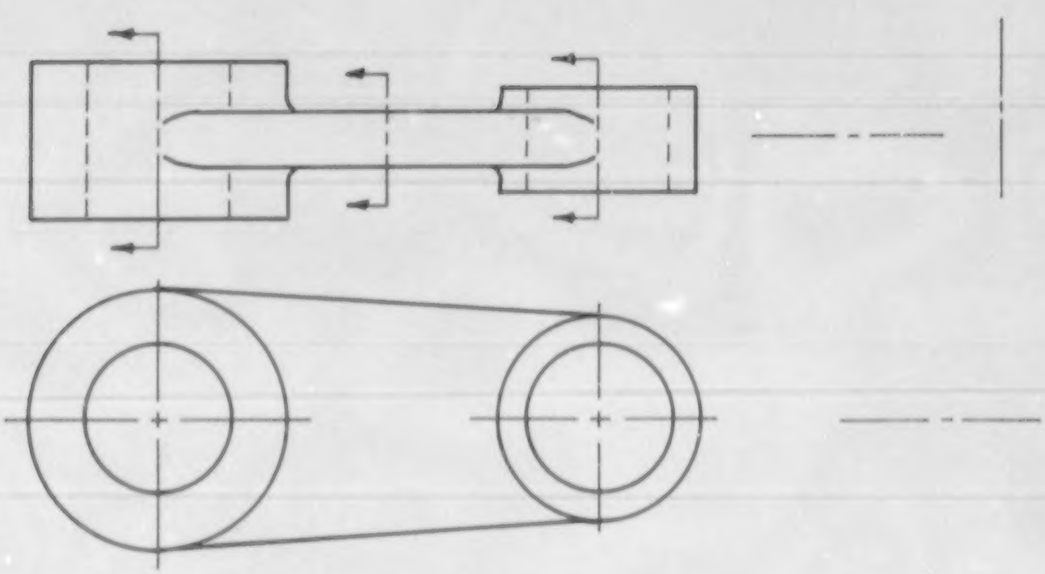
ASSIGNMENT SHEET #6

Directions: Construct the removed sections indicated by cutting plane lines for the following problems. Type of material will be assigned by instructor.

Problem B:



Problem C:



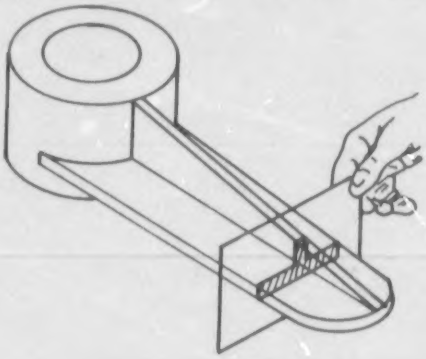
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #7--CONSTRUCT A REVOLVED SECTION OF AN OBJECT

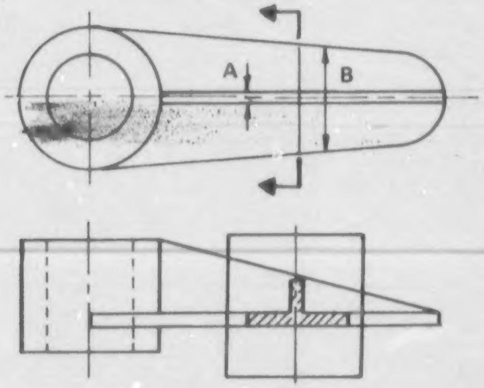
Premise: A revolved section is used to illustrate an area of an object without drawing a separate view. A revolved section of an object can be constructed by using the procedure in the following example.

Example:

1. Pass an imaginary plane through the area

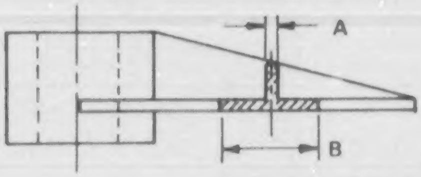


2. Indicate cutting plane line and rotate plane in front view

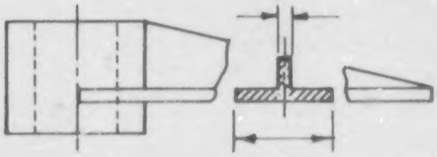


3. The section can be shown in one of two ways (a) drawn in context, or (b) object broken away from section

a.



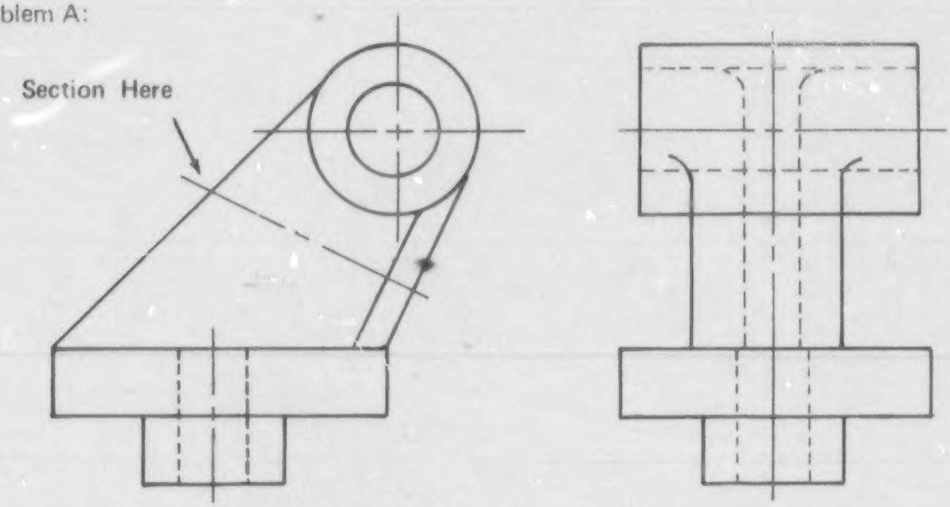
b.



ASSIGNMENT SHEET #7

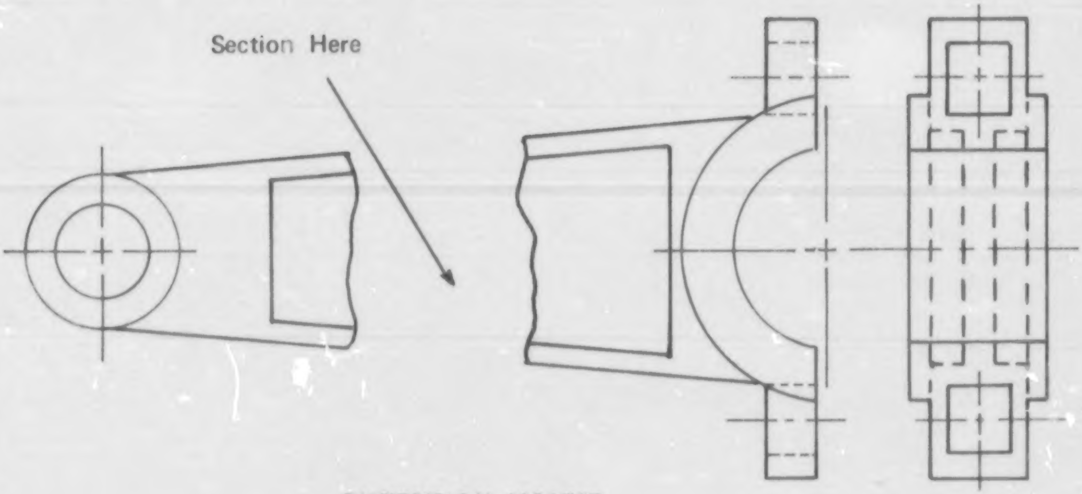
Directions: Construct a section view in the area indicated for the offset bracket and the extension mount.

Problem A:


Section Here

OFFSET BRACKET

Problem B:


Section Here

EXTENSION MOUNT

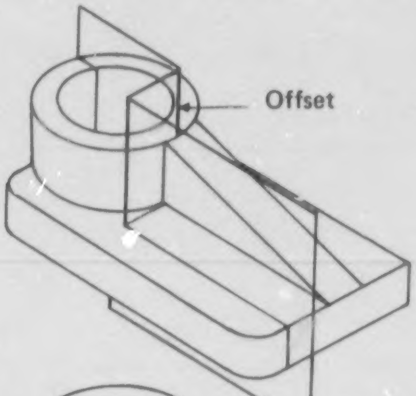
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #8--CONSTRUCT A RIB SECTION OF AN OBJECT

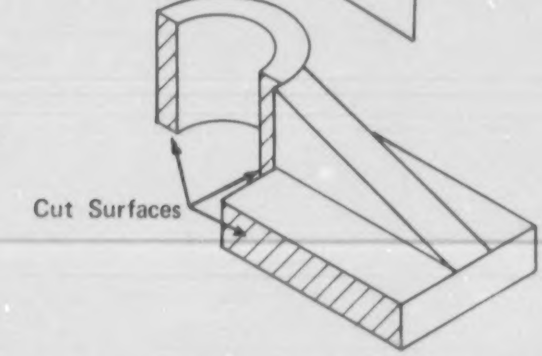
Premise: A rib section of an object can be constructed by using the procedure in the following example.

Example:

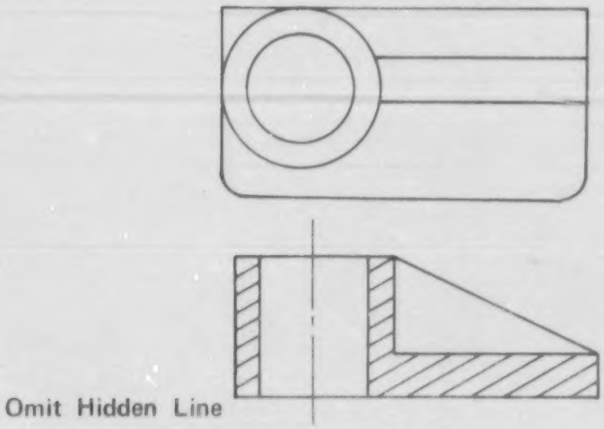
1. When sectioning an area that has a rib or spoke, the cutting plane line offsets in front of the rib



2. Remove front portion and look into the object



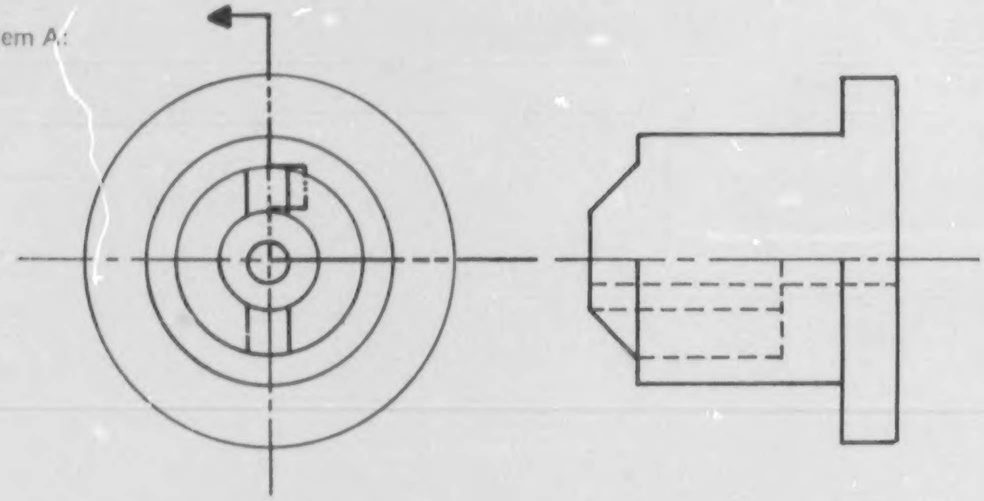
3. Show cutting plane as illustrated in top view; section front view as shown omitting section lines on rib



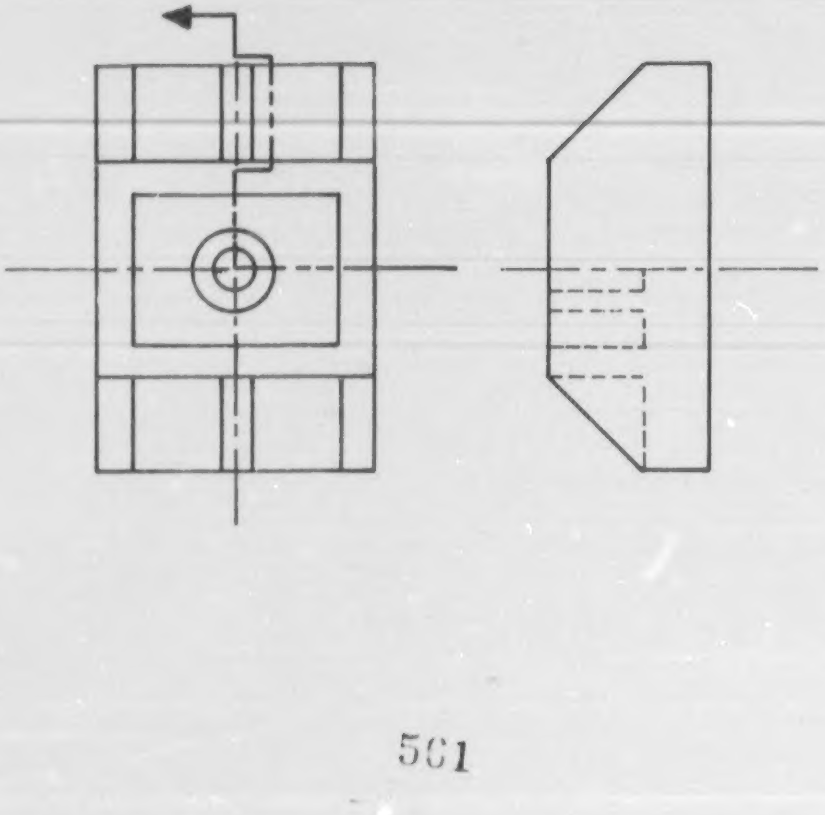
ASSIGNMENT SHEET #8

Directions: Construct the right side view with rib sectioned properly for the following problems.

Problem A:



Problem B:



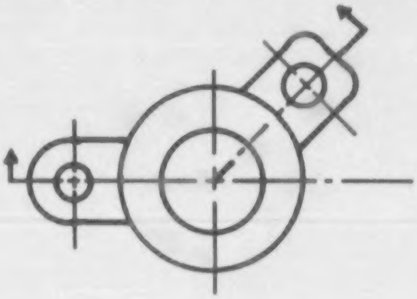
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #9--CONSTRUCT AN ALIGNED SECTION OF AN OBJECT WITH HOLES, RIBS, OR SPOKES

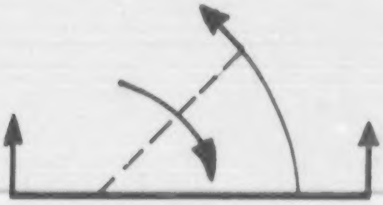
Premise: When the offset is in line with the rest of the object, there is no problem in sectioning. However, when the offsets are not in line, a true projection would be misleading. An aligned section of an object with holes, ribs, or spokes can be constructed by using the procedure in the following example.

Example:

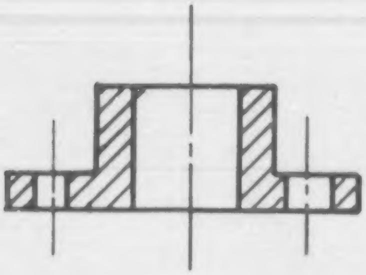
1. Introduce cutting plane line



2. Rotate cutting plane to horizontal axis



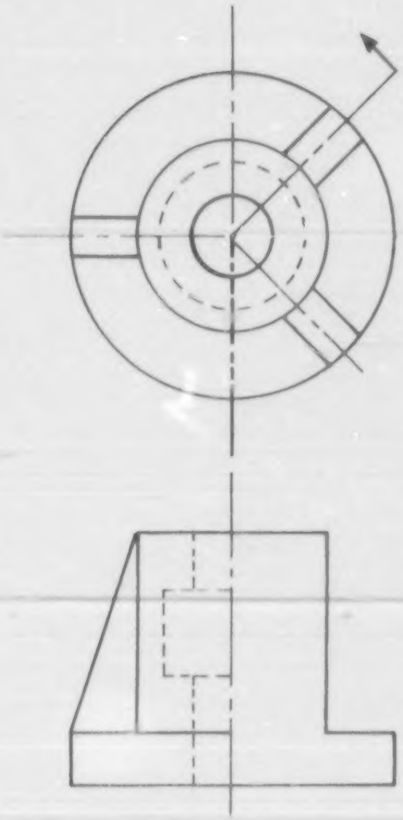
3. Draw in sections as if they were all on horizontal cutting plane



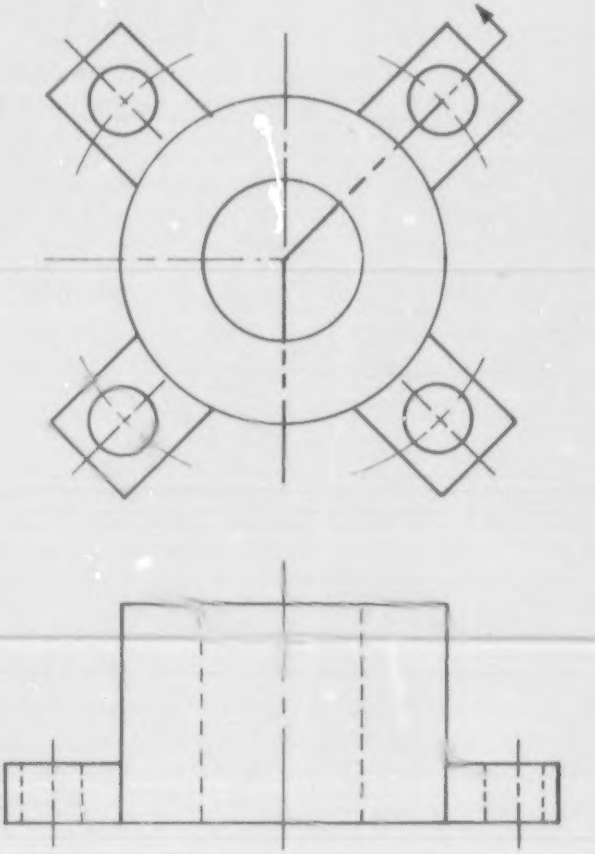
ASSIGNMENT SHEET #9

Directions: Construct front views as aligned sections for the following problems.

Problem A:



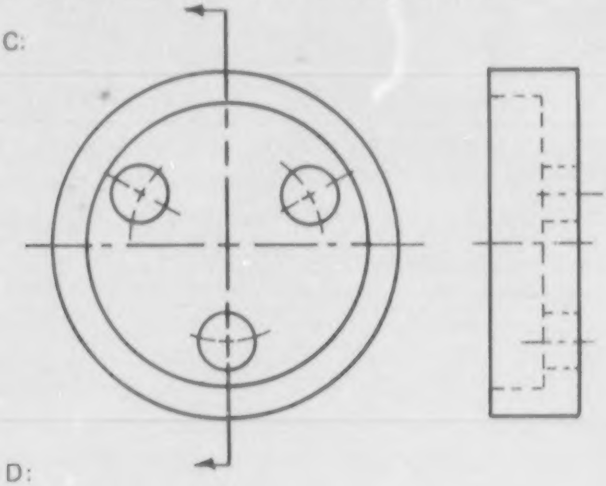
Problem B:



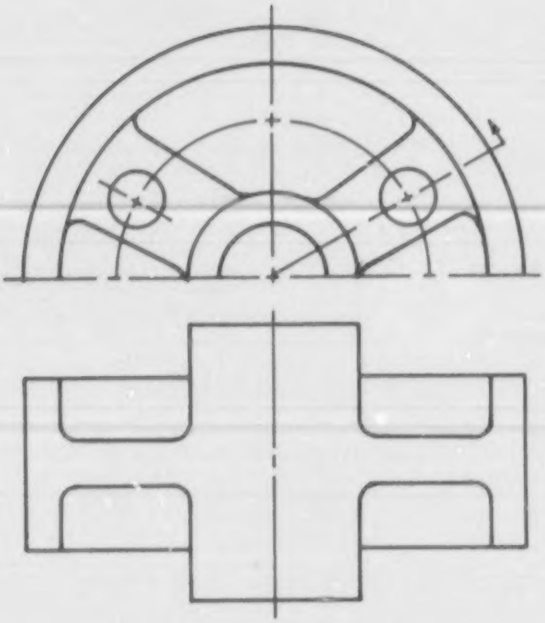
ASSIGNMENT SHEET #9

Directions: Construct the right side into aligned section for the following problems.

Problem C:



Problem D:



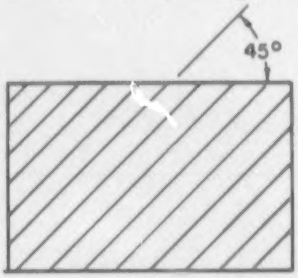
SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #10--CONSTRUCT ADJACENT PARTS IN ASSEMBLY SECTION

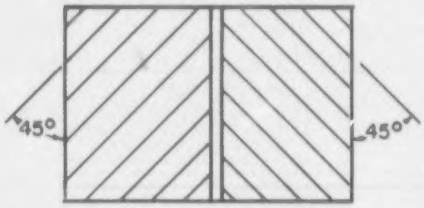
Premise: Adjacent parts in assembly section can be constructed by using the procedure in the following example.

Example:

1. Section lines are constructed at an angle of 45° to the main outline of the object

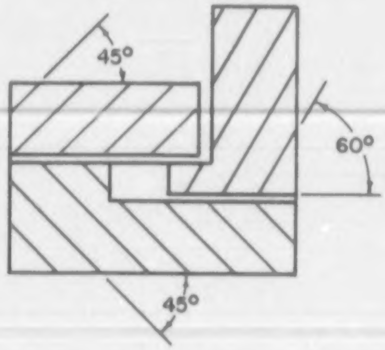


2. On adjacent parts, section lines should be 45° in the opposite direction

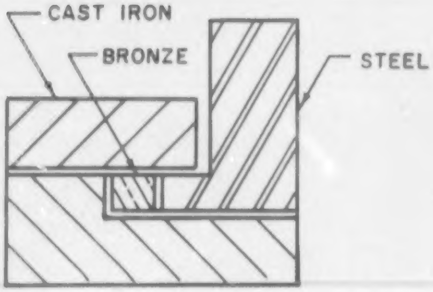


3. For more than two parts adjacent to each other, section lines should be drawn at an angle of 30° or 60°

   (NOTE: Section lines should not be drawn to meet at common lines.)



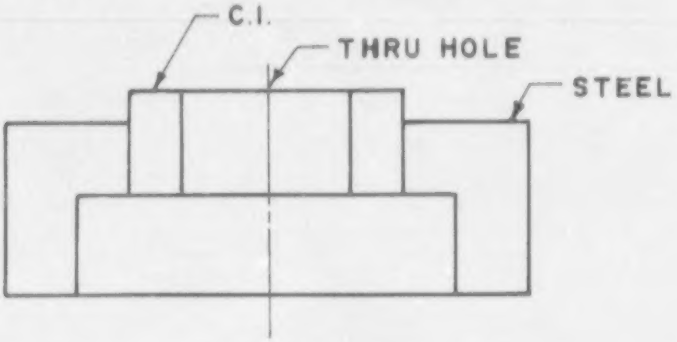
4. Different materials can be used to represent different parts in section



ASSIGNMENT SHEET #10

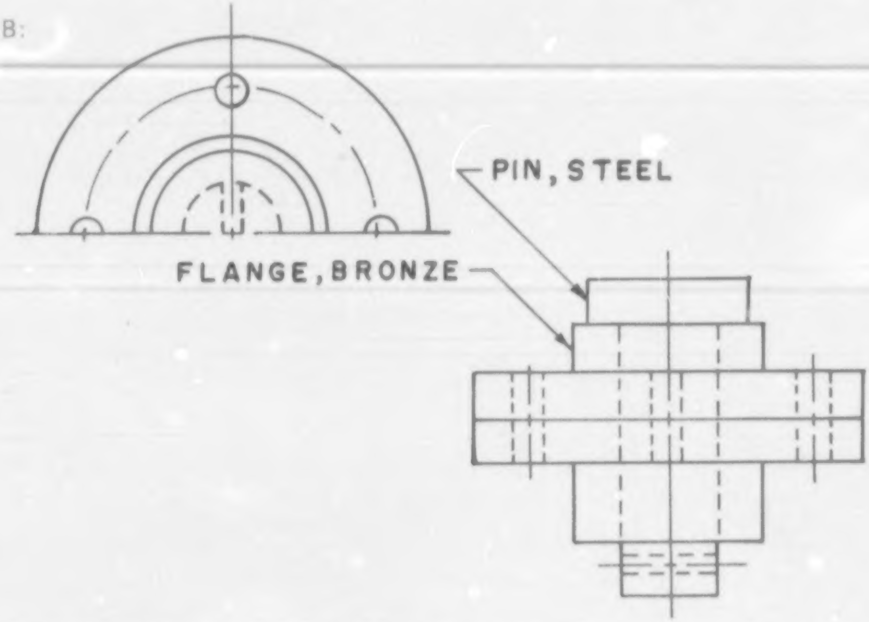
Directions: Complete this assembly as a section using the proper symbols.

Problem A:


C.I.
THRU HOLE
STEEL

Directions: Complete front view as a section using the symbols indicated.

Problem B:


PIN, STEEL
FLANGE, BRONZE

SECTIONAL VIEWS
UNIT VII

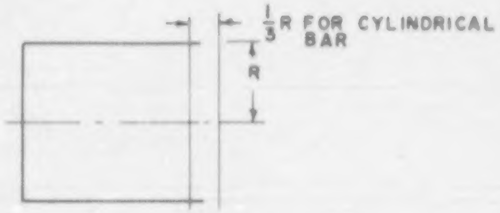
ASSIGNMENT SHEET #11--CONSTRUCT CONVENTIONAL BREAKS

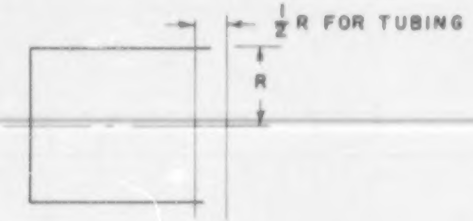
Premise: In constructing a long bar or tubing with uniform cross section, it is usually not necessary to construct its full length. A break is made, sectioned, and the true length of the object is indicated by a dimension. The conventional breaks for cylindrical bars and tubing are known as "S" breaks and may be constructed with templates or free hand. The procedure in the following example is for the use of templates.

Example:

1. Use given rectangular view for bar or tube

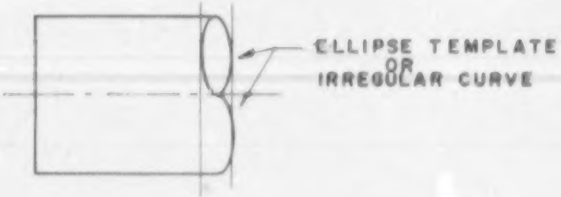
2. Lay off fractional radius widths on end to be sectioned

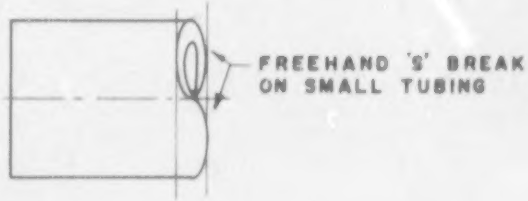

$\frac{1}{3}$R FOR CYLINDRICAL BAR
R


$\frac{1}{2}$R FOR TUBING
R

3. Using ellipse template or irregular curve, construct "S" breaks

   (NOTE: Construct "S" break free hand on small diameter bar or tubing.)

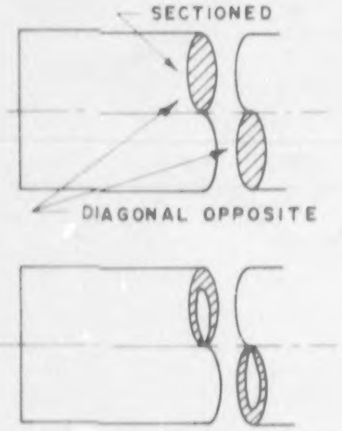

ELLIPSE TEMPLATE OR IRREGULAR CURVE


FREEHAND 'S' BREAK ON SMALL TUBING

ASSIGNMENT SHEET #11

4. Add section lining to visible sectioned part

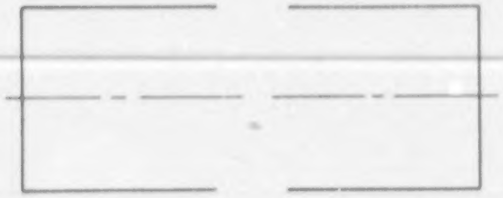
   (NOTE: When "S" break is shown with stock continuing on both sides of break, the sectioned faces are diagonally opposite.)



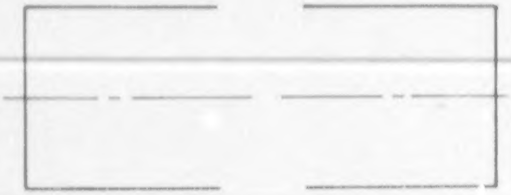
5. Short or long break symbols are used on rectangular solids

Directions: Construct conventional breaks in the parts below.

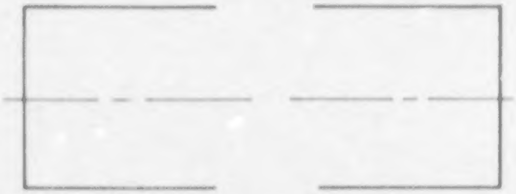
Problem A: Cylindrical -- Cast iron



Problem B: Rectangular -- Steel



Problem C: Tubular -- Brass

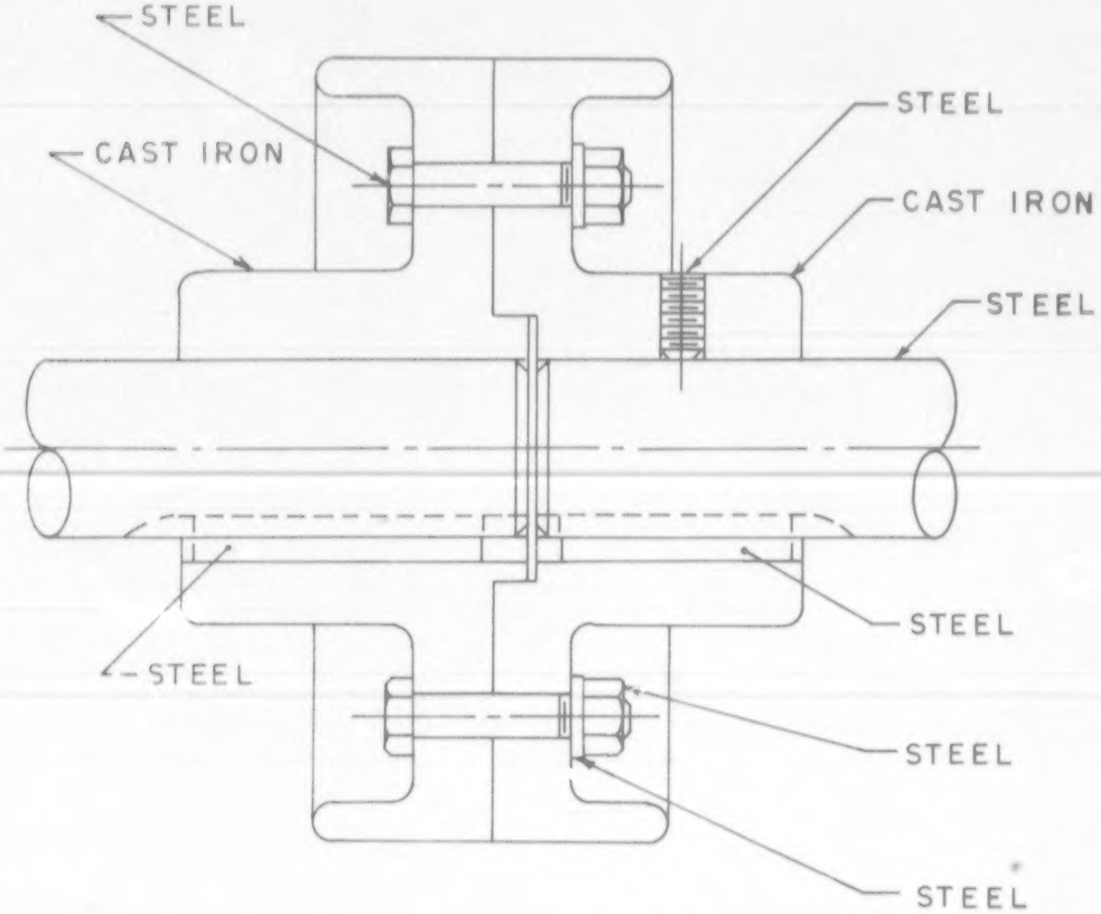


SECTIONAL VIEWS
UNIT VII

ASSIGNMENT SHEET #12--CONSTRUCT AN ASSEMBLY SECTION

Premise: Shafts, bolts, nuts, rods, rivets, keys, pins, and similar parts are not sectioned if the axis lies in the cutting plane. A broken-out section may be used to clarify the key and keyseat.

Directions: Complete a full section of the following coupling assembly using proper material symbols.


STEEL
CAST IRON
STEEL
CAST IRON
STEEL
STEEL
STEEL
STEEL
STEEL

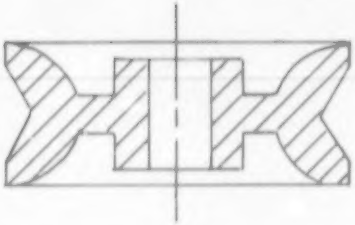
SECTIONAL VIEWS
UNIT VII

ANSWERS TO ASSIGNMENT SHEETS

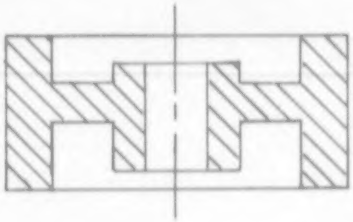
Assignment Sheet #1--Evaluated to the satisfaction of the instructor

Assignment Sheet #2

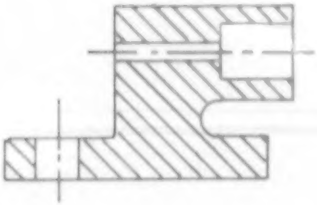
A.



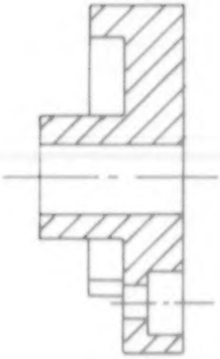
B.



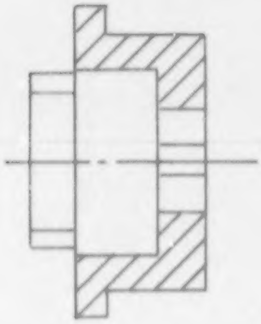
C.



D.

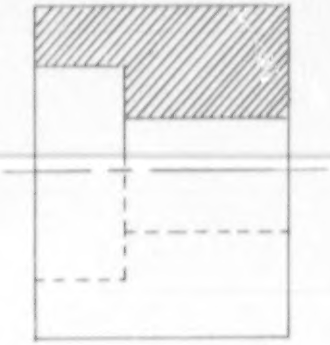


E.

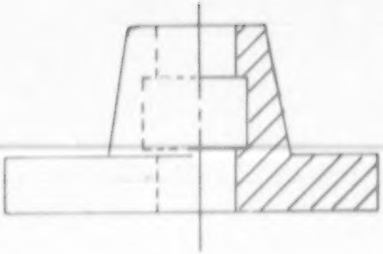


Assignment Sheet #3

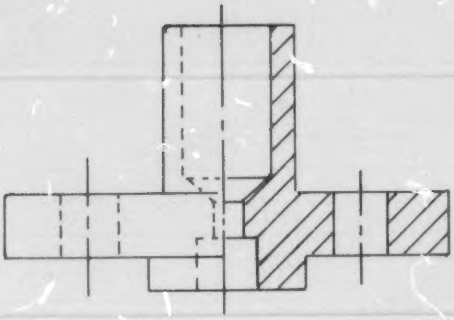
A.



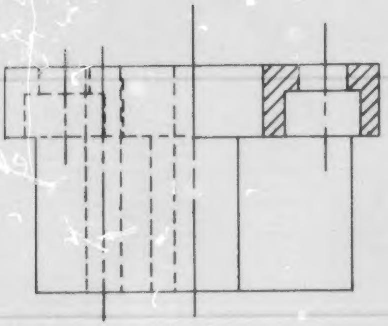
B.



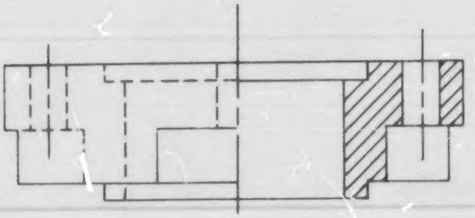
C.



D.

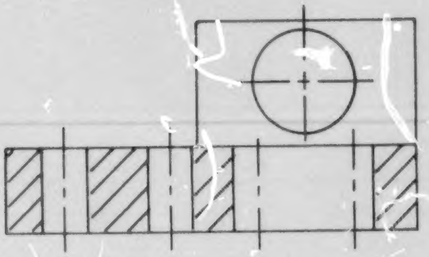


E.



Assignment Sheet #4

A.



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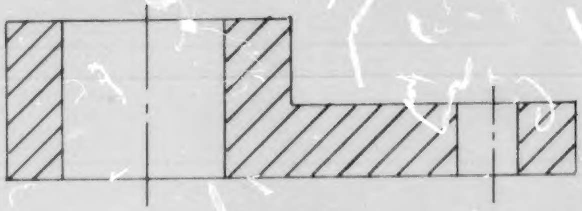
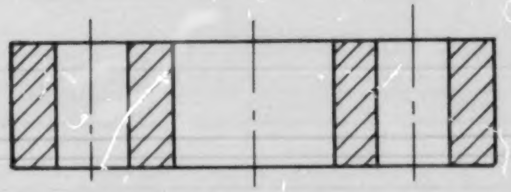
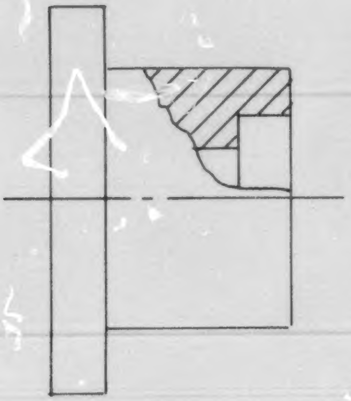


D.



Assignment Sheet #5

A.



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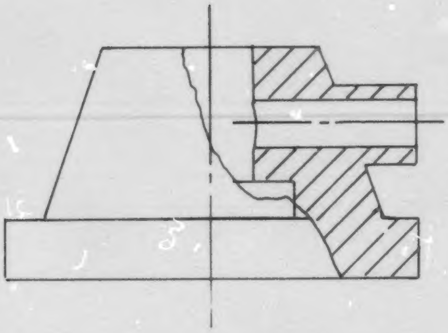
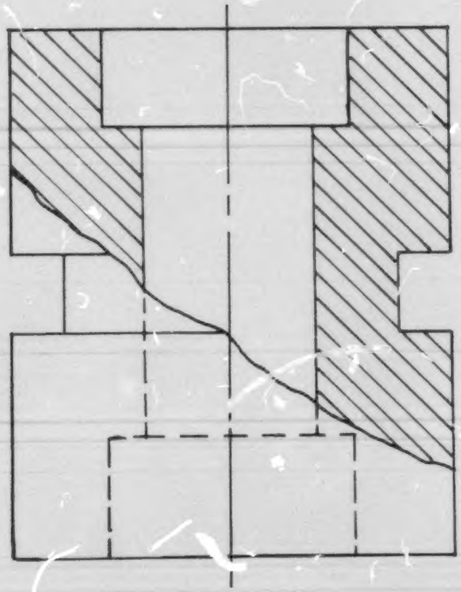


C.



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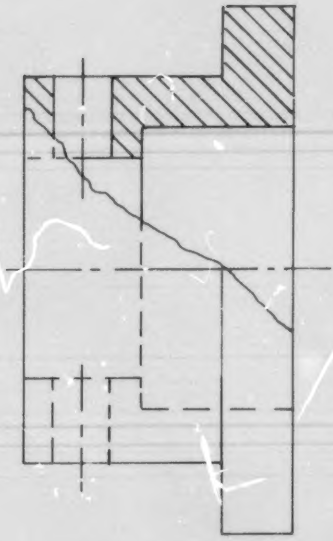
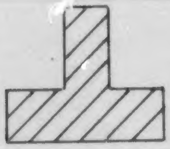
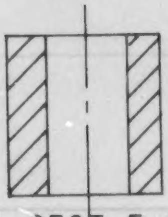


Assignment Sheet #6

A.

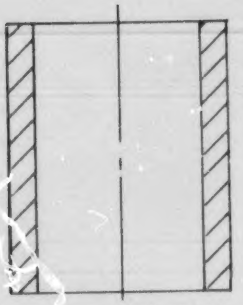


SECT D-D

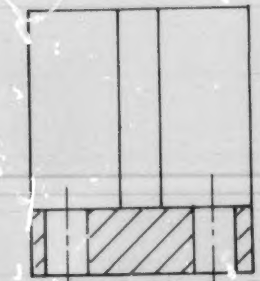


SECT E-E

B.



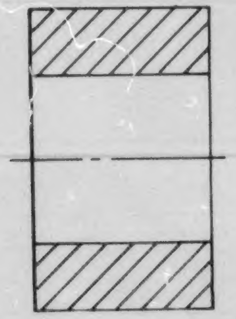
SECTION A-A



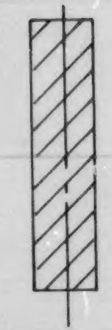
SECTION B-B

Assignment Sheet #6

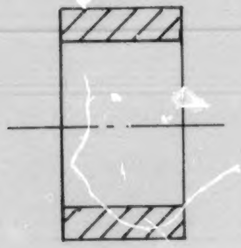
C.



SECTION A-A



SECT B-B

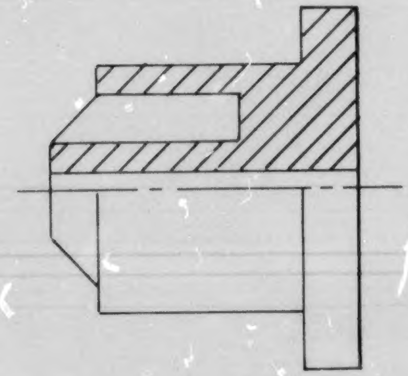


SECT C-C

Assignment Sheet #7--Evaluated to the satisfaction of the instructor

Assignment Sheet #8

A.



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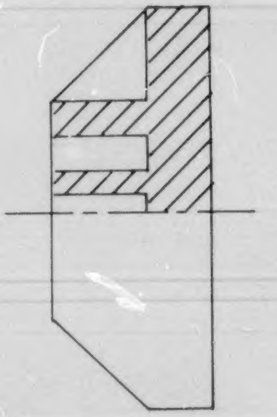
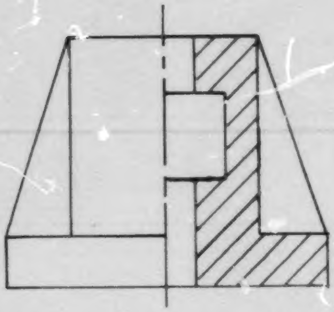


Assignment Sheet #9

A.



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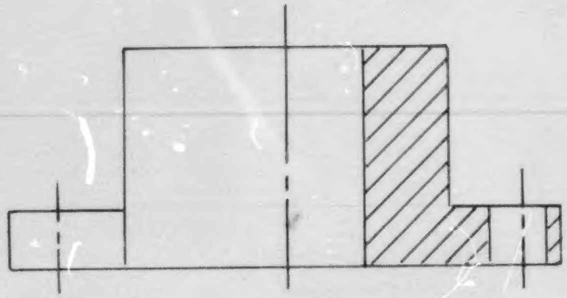
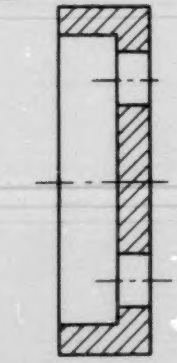
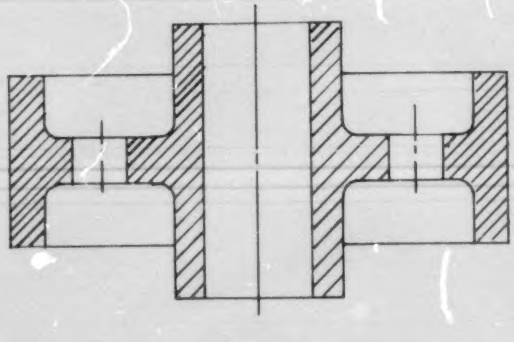


C.

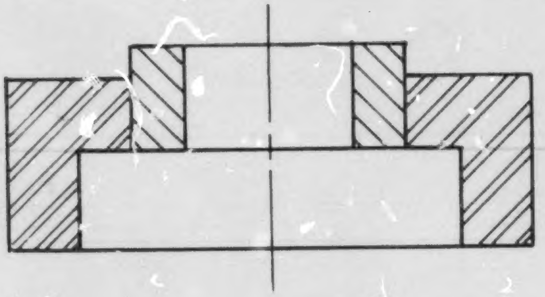


D.

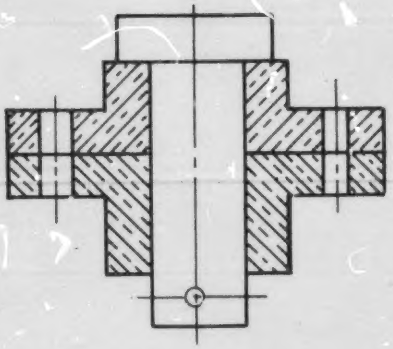


Assignment Sheet #10

A.



B.



Assignment Sheet #11--Evaluated to the satisfaction of the instructor

Assignment Sheet #12--Evaluated to the satisfaction of the instructor

SECTIONAL VIEWS
UNIT VII

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

_____ a. The imaginary cutting away from front viewing portion of the object to show the interior detail

_____ b. The cutting plane passes completely through an object and the cross section behind the cutting plane line is exposed to view

_____ c. A line symbol that is drawn on exposed cut surface; sometimes called cross hatching

_____ d. Symbolic section lining used for indication of various materials

_____ e. An imaginary plane used to cut through an object

_____ f. The cutting planes are passed at right angles to each other along the center lines and one-fourth of object is removed

_____ g. Has a cutting plane line to pick up features that are not along a common cutting plane

_____ h. An area broken out of a view that shows only a portion of that view in section

_____ i. A revolved section drawn off the principal view and placed in another convenient location

_____ j. A cutting plane line is passed through an area and then the image is revolved 90° in position

_____ k. Used to align features such as spokes, holes, and ribs along a common plane so that they can be detailed more easily

_____ l. Materials too thin for section lining are shown solid

1. Section lining
2. Offset section
3. Cutting plane
4. Thin section
5. Aligned section
6. Subtitles
7. Sectional view
8. Symmetry
9. Broken-out section
10. Removed section
11. Rib section
12. Full section
13. Revolved section
14. Unlined section
15. Half section
16. Outline sectioning
17. Assembly section
18. Conventional break
19. Section symbols

______m. Used for clarity in sections of assembly drawings of standard parts where the axis of the part lies in the cutting plane

______n. Used in making a shortened view of a long simple object

______o. Shows all parts of an object as one unit and drawn using section lining to make the individual parts stand out

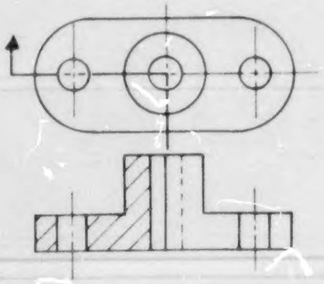
______p. Section lines are shown along the borders of a large part for clarity and to save time

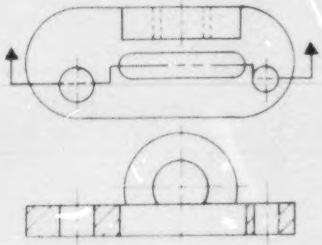
______q. Method of not showing the ribs section lined eliminates the impression of solidity

______r. Having the same shape and size on opposite sides of a center line

______s. Labeling with capital letters the sectional view which has a removed section

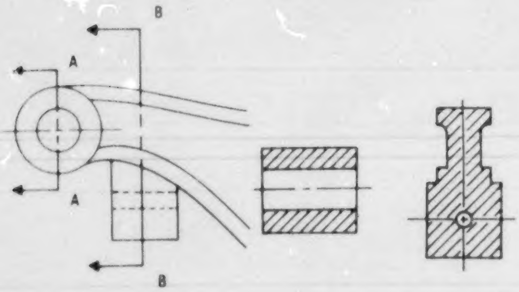
2. Identify types of sectional views.

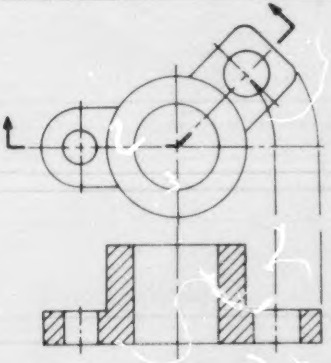




a. ______________________________

b. ______________________________



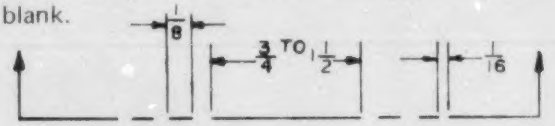


c. ______________________________

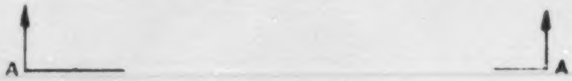
d. ______________________________

6. Select the most commonly used form of cutting plane lines by placing an "X" in the appropriate blank.

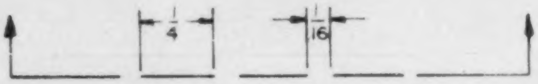
______ a.



______ b.



______ c.



7. Select true statements concerning general rules in sectioning by placing an "X" in the appropriate blanks.

______ a. Hidden lines behind the cutting plane should be omitted unless needed

______ b. Sections which are too thin for effective section lining are shown as broken lines

______ c. Large surfaces are often sectioned only along the edge of the part

______ d. If two or more sections appear on the same drawing, labeling is not necessary

______ e. Section lines are thick wavy lines drawn vertical to main outline of the view

______ f. Section lines are uniformly spaced 1" apart

______ g. Where two or more thin sections are shown, a space should be left between them

______ h. When the cutting plane offsets, a line is always shown in the sectioned view to present the offset

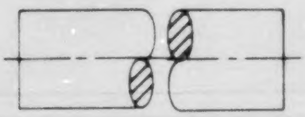
______ i. When objects have one major center line, the cutting plane line may be omitted

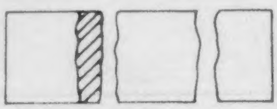
______ j. A center line or a visible line may not be used to divide the sectioned half from the unsectioned half

______ k. Hidden lines cannot be added to unsectioned half for dimensioning

______ l. Visible lines behind cutting plane line should not be omitted

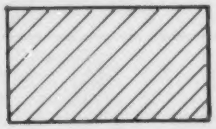
8. Identify types of conventional breaks.



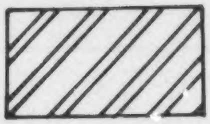


a. ______________________________ b. ______________________________

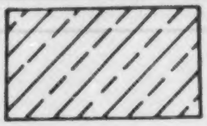
3. Identify material symbols in section.



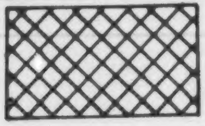
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

4. Match types of sections on the right with their correct uses.

______a. To show both interior and exterior features of a symmetrical object

______b. To show the true shape of the cross section of a long object such as a bar, spoke, rib, or arm

______c. To show features that are not in a straight line

______d. To show interior detail of objects where less than half section is required

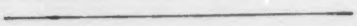
______e. Used for clearness and for easier dimensioning

______f. Replaces an exterior view in order to show some interior details

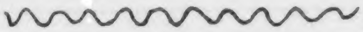
______g. Used when true projection would be confusing for spokes, ribs, and holes

1. Revolved section
2. Broken-out section
3. Half section
4. Aligned section
5. Offset section
6. Removed section
7. Full section

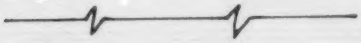
5. Identify line thickness used in sectional drawings.



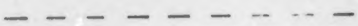
a. ______________________________



b. ______________________________

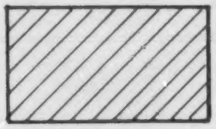


c. ______________________________

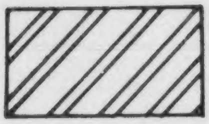


d. ______________________________

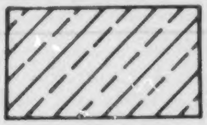
3. Identify material symbols in section.



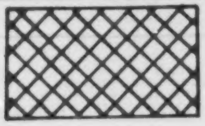
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

4. Match types of sections on the right with their correct uses.

______a. To show both interior and exterior features of a symmetrical object

______b. To show the true shape of the cross section of a long object such as a bar, spoke, rib, or arm

______c. To show features that are not in a straight line

______d. To show interior detail of objects where less than half section is required

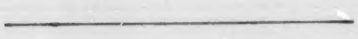
______e. Used for clearness and for easier dimensioning

______f. Replaces an exterior view in order to show some interior details

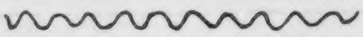
______g. Used when true projection would be confusing for spokes, ribs, and holes

1. Revolved section
2. Broken-out section
3. Half section
4. Aligned section
5. Offset section
6. Removed section
7. Full section

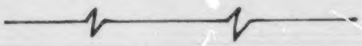
5. Identify line thickness used in sectional drawings.



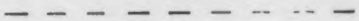
a. ______________________________



b. ______________________________



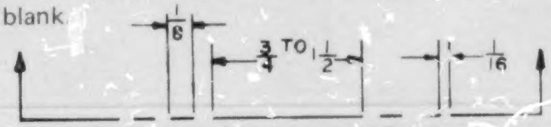
c. ______________________________



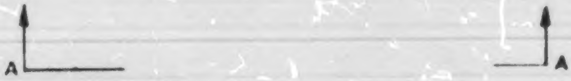
d. ______________________________

6. Select the most commonly used form of cutting plane lines by placing an "X" in the appropriate blank.

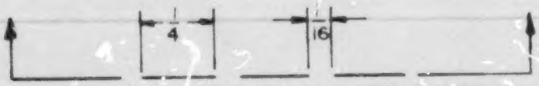
______a.



______b.



______c.



7. Select true statements concerning general rules in sectioning by placing an "X" in the appropriate blanks.

______a. Hidden lines behind the cutting plane should be omitted unless needed

______b. Sections which are too thin for effective section lining are shown as broken lines

______c. Large surfaces are often sectioned only along the edge of the part

______d. If two or more sections appear on the same drawing, labeling is not necessary

______e. Section lines are thick wavy lines drawn vertical to main outline of the view

______f. Section lines are uniformly spaced 1" apart

______g. Where two or more thin sections are shown, a space should be left between them

______h. When the cutting plane offsets, a line is always shown in the sectioned view to present the offset

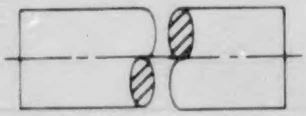
______i. When objects have one major center line, the cutting plane line may be omitted

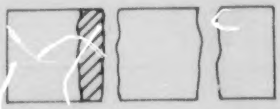
______j. A center line or a visible line may not be used to divide the sectioned half from the unsectioned half

______k. Hidden lines cannot be added to unsectioned half for dimensioning

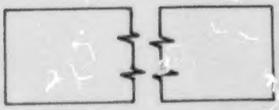
______l. Visible lines behind cutting plane line should not be omitted

8. Identify types of conventional breaks.

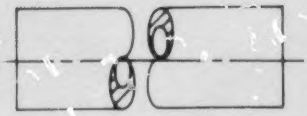




a. ______________________________ b. ______________________________



c. ______________________________



d. ______________________________

9. List three common errors in making section lines.

a. ______________________________

b. ______________________________

c. ______________________________

10. Select true statements concerning use of unlined sections by placing an "X" in the appropriate blanks.

______ a. Thin parts are made solid

______ b. Shafts, bolts, nuts, pins, keys, rivets, gear teeth, and similar parts should always be sectioned if axis lies in cutting plane

______ c. Broken-out section of shaft may be made to indicate clearness of key, keyseat, and pin

11. List three methods used to aid equal spacing of section lining.

a. ______________________________

b. ______________________________

c. ______________________________

12. Select true statements concerning labeling sectional views by placing an "X" in the appropriate blanks.

______ a. More than one removed section view should be labeled with letters corresponding to the ends of the cutting plane line

______ b. Sectional views should be arranged in alphabetical order from right to left on the drawing

______ c. Section letters should be used in alphabetical order

______ d. Letters "B", "C", and "X" should not be used

13. Demonstrate the ability to:

a. Construct various material symbols in section.

b. Construct a full section of an object.

c. Construct a half section of an object.

d. Construct an offset section of an object.

e. Construct a broken-out section of an object.

f. Construct a removed section of an object.

g. Construct a revolved section of an object.

h. Construct a rib section of an object.

i. Construct an aligned section of an object with holes, ribs, or spokes.

j. Construct adjacent parts in assembly section.

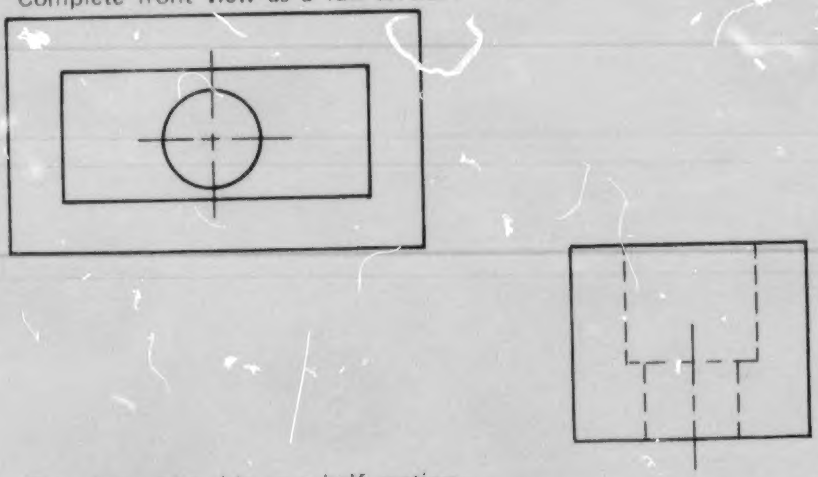
k. Construct conventional breaks.

l. Construct an assembly section.

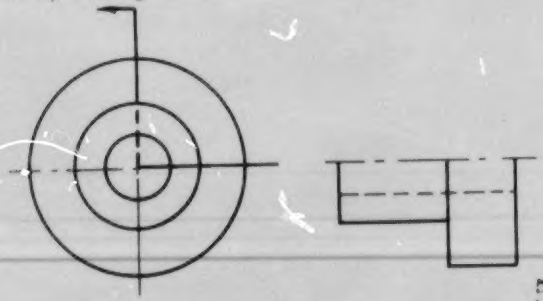
(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

14. Construct various sectional views.

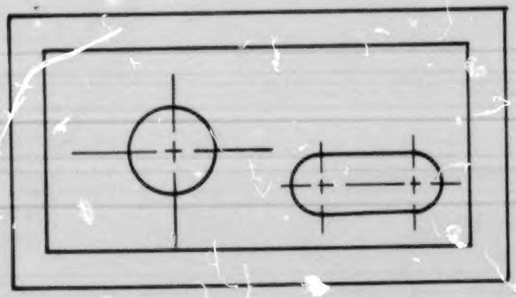
a. Complete front view as a full section.

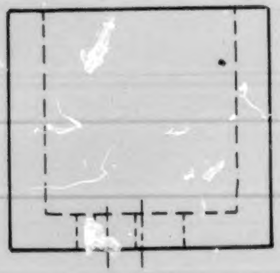


b. Complete right side as a half section.



c. Complete front view as an offset section.





SECTIONAL VIEWS
UNIT VII

ANSWERS TO TEST

1. a. 7
   b. 12
   c. 1
   d. 19
   e. 3
   f. 15
   g. 2
   h. 9
   i. 10
   j. 13
   k. 5
   l. 4
   m. 14
   n. 18
   o. 17
   p. 16
   q. 11
   r. 8
   s. 6

2. a. Half section
   b. Offset section
   c. Removed section
   d. Aligned section

3. a. Cast iron
   b. Steel
   c. Brass, bronze, or copper
   d. Zinc, lead, and alloys

4. a. 3
   b. 1
   c. 5
   d. 2
   e. 6
   f. 7
   g. 4

5. a. Section line, thin
   b. Short break line, thick
   c. Long break line, thin
   d. Hidden line, thin

6. a.

7. a, c, g, i, l

8. a. Round bar
   b. Rectangular solid
   c. Long break
   d. Round tubular

9. Any three of the following:
   a. Irregular spacing
   b. Varying line weight
   c. Lines too thick
   d. Lines short or over run visible lines

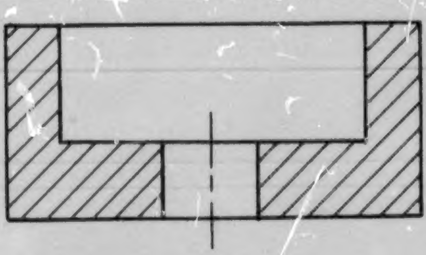
10. a, c

11. Any three of the following:
   a. Visual spacing
   b. Line guide
   c. Trace lines from a grid sheet
   d. Measure with scale

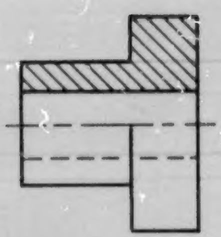
12. a, c

13. Evaluated to the satisfaction of the instructor

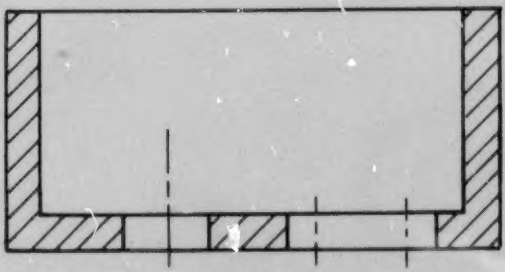
14. a.



b.



c.



INKING TOOLS AND TECHNIQUES
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to select types of inks, their quality requirements, properties, and performance and types of pen points. The student should also be able to draw and erase ink lines on various media and clean, fill, and refill various types of pens. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to inking tools and techniques with their correct definitions.
2. Select types of drawing inks.
3. Select quality requirements of good drawing ink.
4. Select true statements concerning the properties and performance of drawing inks.
5. List three types of pen points.
6. Select true statements concerning the ways to properly use and care for technical pens.
7. Complete statements concerning procedures for matching microfilmed drawings.
8. List ways to properly use technical pens with programmed automated digital plotters.
9. Select true statements concerning precautions when using ink on vellum or tracing cloth.
10. Select true statements concerning characteristics of polyester film and procedures for using ink on polyester film.
11. Select factors that contribute to making a line heavier with a ruling pen.
12. Select factors that contribute to making a line thinner with a ruling pen.
13. Discuss useful tips for working with ink.
14. Complete a chart of the alphabet of ink lines.

15. Demonstrate the ability to:

    a. Draw and erase ink lines on vellum or tracing cloth.

    b. Draw and erase ink lines on polyester film.

    c. Complete steps in inking a drawing or a tracing.

    d. Fill clean technical and pocket model pens.

    e. Refill a technical pen.

    f. Clean technical and pocket model pens using the standard cleaning method.

    g. Clean a technical pen with an ultrasonic cleaner.

INKING TOOLS AND TECHNIQUES
UNIT VIII

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information, assignment, and job sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Demonstrate and discuss the procedures outlined in the job sheets.

VII. Demonstrate the use of and the advantages and disadvantages of the electric eraser and the ultrasonic pen cleaner.

VIII. Complete Job Sheet #1 before starting assignment sheets.

IX. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Technical Pen Parts
    2. TM 2--Pen Point
    3. TM 3--Manual Lettering Device
    4. TM 4--Calligraphic Lettering and Ruling Pens
    5. TM 5--Visible, Hidden, Center, and Symmetry Lines
    6. TM 6--Section, Extension, Dimension, and Leader Lines
    7. TM 7--Cutting Plane, Short Break, and Long Break Lines
    8. TM 8--Phantom, Stitch, Chain, and Border Lines
    9. TM 9--Line Applications

D. Assignment sheets

1. Assignment Sheet #1--Draw and Erase Ink Lines on Vellum or Tracing Cloth
2. Assignment Sheet #2--Draw and Erase Ink Lines on Polyester Film
3. Assignment Sheet #3--Complete Steps in Inking a Drawing or a Tracing

E. Job sheets

1. Job Sheet #1--Fill Clean Technical and Pocket Model Pens
2. Job Sheet #2--Refill a Technical Pen
3. Job Sheet #3--Clean Technical and Pocket Model Pens Using the Standard Cleaning Method
4. Job Sheet #4--Clean a Technical Pen With an Ultrasonic Cleaner

F. Test

G. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry*. South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

B. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing*. New York 10022: Macmillan Publishing Co., Inc., 1968.

C. Giesecke, Frederick E., et al. *Technical Drawing*. New York 10022: Macmillan Publishing Co., Inc., 1980.

D. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design*. New York: Gregg Division/McGraw-Hill Book Co., 1979.

E. Spence, William P. *Drafting Technology and Practice*. Peoria, IL 61615: Chas. A. Bennett Co., Inc., 1973.

F. Spence, William P. and Michael B. Atkins. *Technical Drafting Metric Design and Communication*. Peoria, IL 61615: Chas A Bennett Co., Inc., 1980.

G. Koh-I-Noor. *Rapidraw Learning Program Workbook*. Bloomsbury, NJ: Koh-I-Noor Rapidograph, Inc.

H. *The Koh-I-Noor Rapidraw System*. Bloomsbury, NJ: Koh-I-Noor Rapidograph, Inc.

I. American National Standards Institute. *Line Conventions and Lettering*. New York: The American Society of Mechanical Engineers, 1979.

INKING TOOLS AND TECHNIQUES
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

A. Opaque--Does not allow light to pass through

B. Transparent--Has the property of transmitting or allowing light to pass through

C. Vellum--Tracing paper which has been treated with a transparentizing agent which normally consists of waxes, oils, and similar substances

D. Tracing cloth--Fabric that has undergone a transparentizing process and is sized with a type of starch compound or plastic to provide a good working surface for pencil or ink

(NOTE: Although tracing cloth is commonly referred to as linen, it is usually made of muslin.)

E. Polyester drafting film--A tough translucent plastic drafting medium, usually made by bonding a matte surface to one or both sides of a clear polyester sheet

(NOTE: Polyester drafting film is dimensionally stable and its size changes very little as humidity and temperature change; it withstands much erasing, is almost impossible to tear, and is moisture resistant.)

F. Matte--Lacking or deprived of gloss or lustre

G. Ink--A liquid composed mainly of carbon in colloidal suspension (latex or solutions of special shellac) and gum

(NOTE: Fine particles of carbon give ink its deep dark, black appearance, and the gum makes it quick to dry and waterproof.)

H. Technical pen--Usually consists basically of a pen holder, ink cartridge, a point, and a cap (Transparency 1)

(NOTE: This is sometimes referred to as a technical fountain pen.)

I. Nib--Pen point

J. Pen point--Device which consists of a shoulder of metal or plastic in a cylinder placed in a plastic color-coded point tube with an air channel and vent hole, a wire-weight, and a wire-weight safety cap (Transparency 2)

(NOTE: Pen point width size may vary with the manufacturer; for example, Koh-I-Noor 6 x 0 to 14, Staedtler-Mars 5 x 0 to 6.)

K. Adhesion--Firm or steady attachment

INFORMATION SHEET

L. Compatible--Capable of forming an homogenous (single) mixture that does not separate or alter by chemical interaction with each individual substance or material

M. Feathering--Occurs when an ink line spreads in an uneven fashion; usually due to drawing on the wire side of the vellum

N. Wire side--Side of the paper that is down when paper goes through a paper-making machine

(NOTE: This wire side can usually be determined by the watermark being backwards.)

O. Felt side--Side of the paper that is up when paper goes through a paper-making machine

(NOTE: The felt side can usually be determined by being able to read the watermark properly.)

P. Watermark--A distinctive mark or design produced by the raised pattern of the dandy roll on the wet sheet; usually used as a trademark

Q. Dogboning--When ink lines spread out at the beginning and end of a line

R. Ultrasonic pen cleaner--Device which uses millions of microscopic bubbles to clean the point of a technical pen

S. Ink triangle--A straight-edged three sided device whose total angles equal 180° made of thin, flat plastic, or metal with acute angles of 45° or angles of 30° and 60° with one or both sides bevelled so that ink will not run under triangle

T. Ink riser--Thin plastic template placed under a template or triangle so that ink will not run under template or triangle

U. Compass adapter--A device for technical pens to hold the pen in the proper position in a compass (Transparency 2)

V. Manual lettering device--An instrument consisting of a lettering template, scriber, and a tubular pen or a technical pen made for scriber use (Transparency 3)

W. Tubular pen--Pen device that fits into a scriber; consists of a pen point and a cleaning pin (Transparency 3)

(NOTE: Tubular pen sizes vary from 4 x 0 to 14 depending on the manufacturer.)

INFORMATION SHEET

X. Calligraphic lettering pen--A fast lettering, freehand drawing pen with an ink reservoir; it is used for calligraphic (beautiful or elegant) handwriting by card writers, commercial artists, drafters, and letterers (Transparency 4)

(NOTE: The Speedball (registered trademark) lettering pen is a typical calligraphic lettering pen.)

Y. Ghosting--A smudged area or image on a reproduction copy of a drawing caused by a damaged surface due to erasing or mishandling of the original

II. Types of drawing inks

A. Washable, opaque

B. Permanent or waterproof black

C. Transparent colors

D. Opaque colors

(NOTE: Acetate-based ink should not be used in a technical pen unless the pens are specifically made for acetate-based inks or damage to the pen will result. Acetate-based inks have a tendency to dry out faster and therefore will clog up the nib faster requiring more frequent cleaning.)

III. Quality requirements of good drawing ink

A. Must be flowing

B. Must be opaque

C. Must have good adhesion to the media surface

D. Must be fast-drying

E. Must dry to sufficient hardness to resist chipping and flaking

F. Must be able to be erased easily at any later date without severe damage to the media surface

(NOTE: Experimentation is sometimes desirable to determine the choice of inks, since not all are compatible with media surfaces. Check with manufacturer for use.)

IV. Properties and performance of drawing inks

(NOTE: The history of China or India ink dates back as far as 2500 B.C.)

A. During manufacturing, drawing inks undergo many chemical and physical tests

INFORMATION SHEET

B. Salts and other impurities can cause the carbon particles to settle out of the ink and seriously affect the ink mixture

C. The solvents in ink will rapidly evaporate and result in thickened ink unless the bottle of ink is capped after each use

D. When using drawing materials that are not chemically compatible, the ink lines tend to flake, chip, feather, and lose sharpness

E. In recent years manufacturers of drawing ink have started using latex as a binder to replace shellac; this causes the ink to be waterproof after curing and produces an extremely dense black ink line

F. Ballpoint pens use an offset ink which is pasty and requires considerable pressure to draw a line; it leaves an irregular line and produces poor contrast

G. Ballpoint pens should not be used for hand drawing; however, they are sometimes used in programmed automated digital plotters when accuracy is not required

V. Types of pen points

A. Stainless steel (for hand use and programmed automated digital plotters)

(NOTE: Stainless steel pen points encased in plastic for hand use are available in larger sizes such as Staedtler Mars #6.)

B. Jewel (for hand use and programmed automated digital plotters)

(NOTE: The jewel point can fracture if it is dropped, or if the point should meet with impact on a hard surface; therefore, do not tap a pen with a jewel point on the desk top.)

C. Tungsten-Carbide (for use with programmed automated digital plotters)

(NOTE: Manufacturers of technical pens and pen points include the following: 1) Koh-I-Noor Rapidograph, Inc., 2) J.S. Staedtler, Inc., 3) Keuffel & Esser Co., 4) Faber Castell, 5) Reform Reforgraph, 6) Polygraph, and other brands which may be available in your location. Check with your local technical pen dealer or manufacturer for technical assistance.)

VI. Ways to properly use and care for technical pens

A. The proper way to hold the technical pen is vertically, with a very light touch

B. While drawing, always pull the technical pen; never push it

C. The air channel allows air to enter the ink cartridge in order to replace the ink that has been used

INFORMATION SHEET

D. The technical pen should always be capped when not in use (even if not used for a short period of time)

E. The wire-weight should never be removed during cleaning, especially sizes .30mm #00 or smaller (Transparency 2)

F. When a technical pen is to be stored for an extended period of time, it should be cleaned well and filled with pen cleaning solution

(NOTE: Check with the manufacturer for recommendation.)

G. Before using a pen that has been stored a long time, flush it with warm water, thoroughly dry it, and refill it with ink

VII. Procedures for matching microfilmed drawings

A. When reducing a microfilmed drawing to the next lower size, use a pen point one size smaller than was used on the original drawing

Example: When a .70 mm (2 1/2) pen has been used on an E size original drawing and the reproduction is to be blown back to a D size drawing, a .50 mm (2) pen should be used

B. When enlarging a microfilm drawing to the next larger size, use a pen point one size larger than was used on the original drawing

Example: When a .70 mm (2 1/2) pen has been used on a D size original drawing and the reproduction is to be blown back to an E size drawing, a .80 mm (3) pen should be used

VIII. Ways to properly use technical pens with programmed automated digital plotters

A. Plotter pen points require instantaneous start-up and shut-off of ink flow

B. Jewel and tungsten points are usually recommended for automatic plotter used on polyester film

C. The wire-weight should never be removed during cleaning, especially in sizes .30 mm #00 or smaller

D. The average speed for hand drafting is 4 inches per second, but some automated plotters draw as fast as 40 inches per second, and this requires exacting pen performance

IX. Precautions when using ink on vellum or tracing cloth

A. Be sure felt side of vellum is up; feathering will result if linework is placed on the wire side

B. Be sure dull side of tracing cloth is up

INFORMATION SHEET

   C. Before putting any linework on vellum or tracing cloth, they should be cleaned and the cleaning material removed

   D. Ink is difficult to remove from vellum or tracing cloth because they are porous materials, so work with care

   E. When linework is erased, it may leave a "ghosting" effect when reproduced, so erase with care

X. Characteristics of polyester film and procedures for using ink on polyester film

   A. If the polyester film is matte on both sides, draw on either side; if it is matte on only one side, place the matte (dull) side up for drawing

   B. Before putting any linework on polyester film, the film should be wiped clean with a moist paper towel

   (NOTE: For serious soils, use a liquid film cleaner.)

   C. Ink can be easily removed from polyester film because the ink does not penetrate into the film

   D. When desired, old ink lines can be removed easily from polyester film

   E. Ink lines will flake or chip off the drafting film when some foreign materials are present between the ink line and the polyester film (Transparency 4)

   F. The matte coating (sometimes called tooth) is applied to polyester film so a line will adhere securely to the surface

   G. For hand drafting, the most common thickness used is 3 mil

XI. Factors that contribute to making a line heavier with a ruling pen (Transparency 4)

   A. Moving the pen too slowly

   B. Overfilling the pen

   C. Dull nibs

   D. Leaning the pen toward the paper

   E. Soft working surface

   F. Dried ink particles caked on the nibs

XII. Factors that contribute to making a line thinner with a ruling pen (Transparency 4)

   A. Moving the pen too fast

   B. Not enough ink in the pen

INFORMATION SHEET

C. Nibs too sharp

D. Pen held to nearly vertical

E. Hard working surface

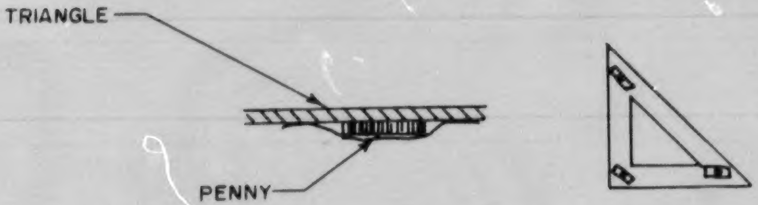
F. Clean pen and fresh ink

(NOTE: A clean, freshly-filled pen should be tested on the same media you will be drawing on, and it should be tested with a straight edge, never freehand.)

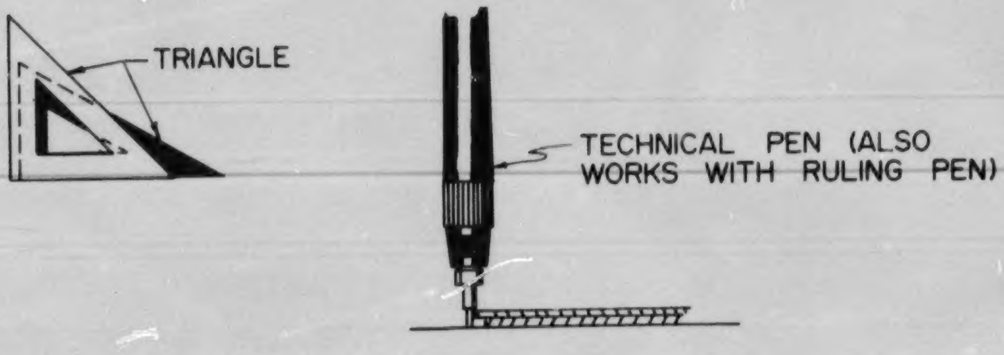
XIII. Useful tips for working with ink

A. If an ink triangle is not available, use pennies or crafting tape on one side of the triangle to raise the triangle off the paper

(NOTE: This can also be done with an irregular curve.)

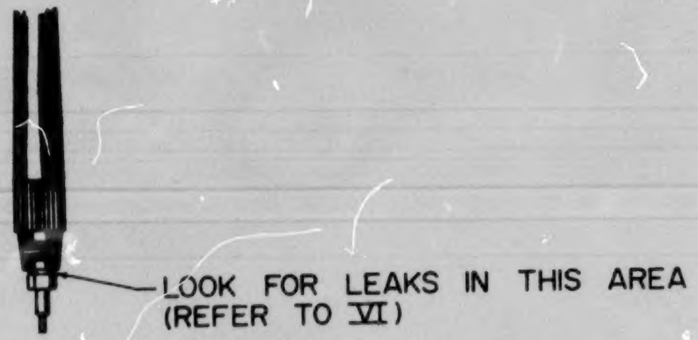


B. If an ink riser is not available, place another triangle under the one being used to prevent ink from flowing under the triangle

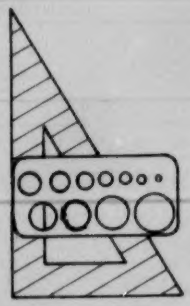


INFORMATION SHEET

C. Periodically check the technical pen for leaking around the tip to prevent your hands from smearing the drawing; also check the tip for a drop of ink on the tip

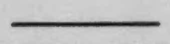
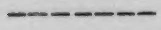
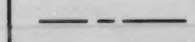
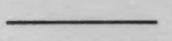
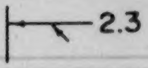
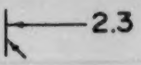
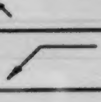
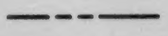
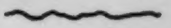
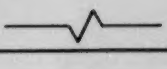
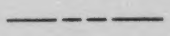
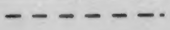
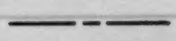
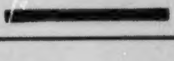


D. If an ink riser is not available, place the template over a triangle to raise the template off the paper; the triangle gives good support and adequate clearance to prevent ink from running under template



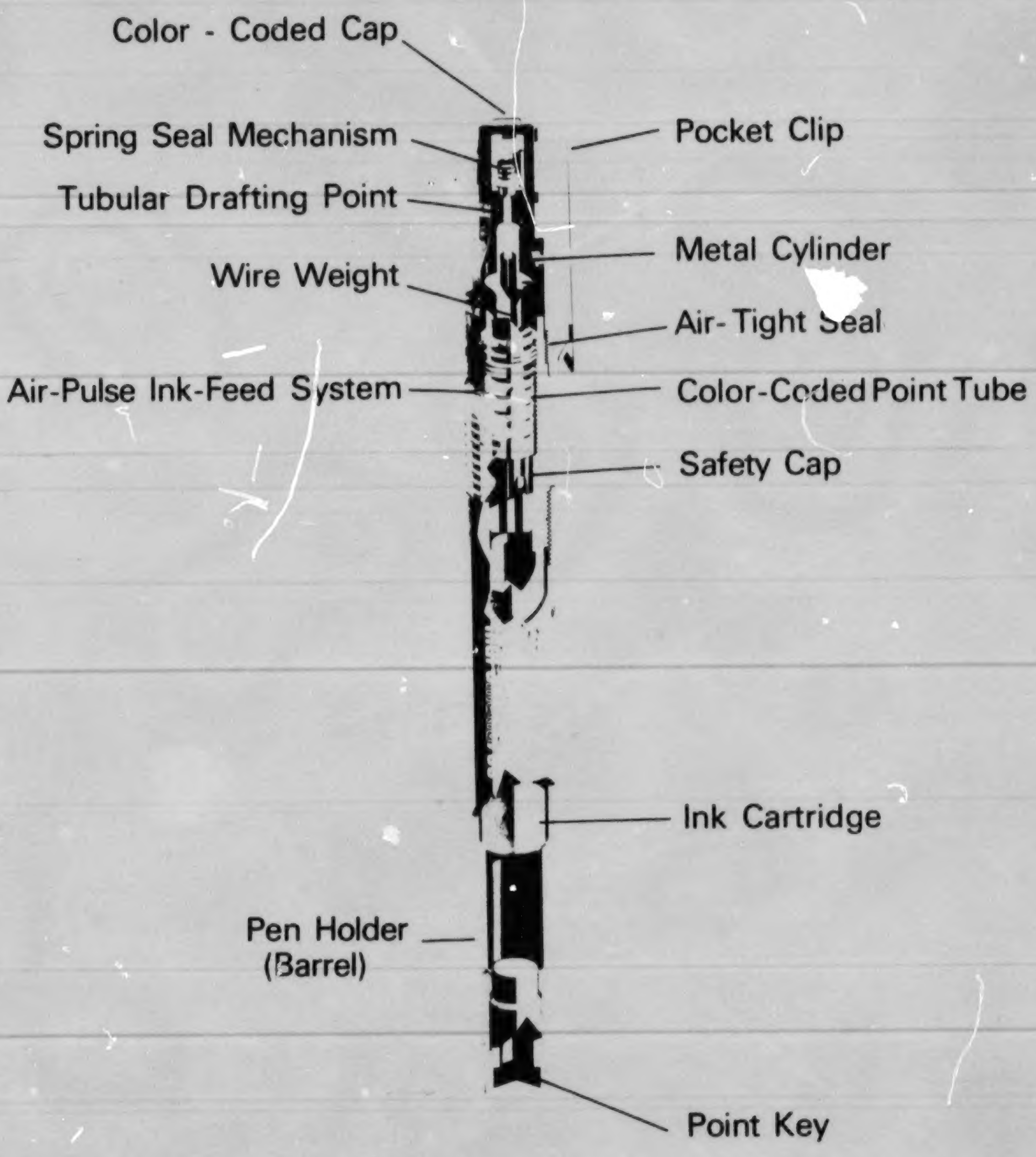
INFORMATION SHEET

XIV. Alphabet of ink lines (Transparencies 5, 6, 7, and 8)

Name of line	Dimension	Approximate Width in in.	Recommended Pen size and number	Figure
Visible line	Thick	.030-.038	.50 mm 2	
Hidden line	Thin	.015-.022	.35 mm 0	
Center line (Symmetry line)	Thin	.015-.022	.35 mm 0	
Section line	Thin	.015-.022	.35 mm 0	
Dimension line	Thin	.015-.022	.35 mm 0	
Extension line	Thin	.015-.022	.35 mm 0	
Leader line	Thin	.015-.022	.35 mm 0	
Viewing plane or Cutting plane	Thick	.030-.038	.50 mm 2	
Short break line	Thick	.030-.038	.50 mm 2	
Long break line	Thin	.015-.022	.35 mm 0	
Phantom line or Adjacent part line	Thin	.015-.022	.35 mm 0	
Stitch line	Thin	.015-.022	.35 mm 0	
Chain line	Thick	.030-.038	.50 mm 2	
Border line	Thick	.038+	.80 mm 3	

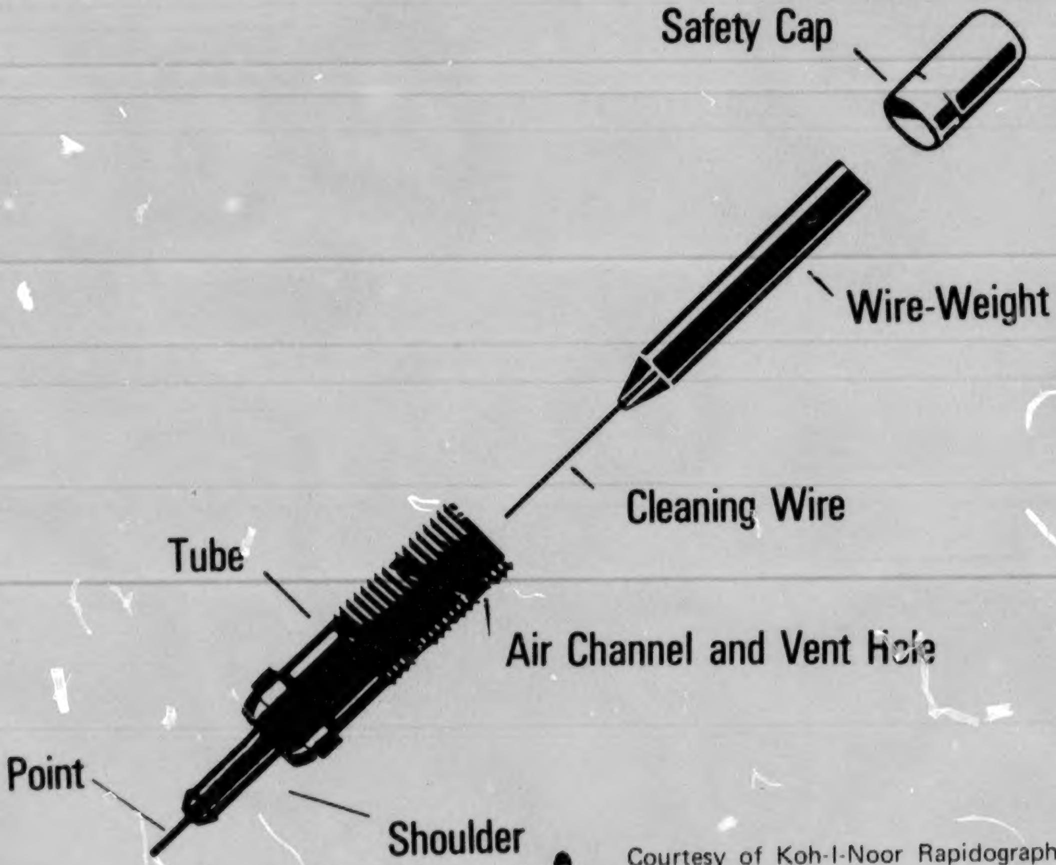
(NOTE: Symmetry lines are used in partial views or sections and are indicated by two short, thick parallel lines drawn at right angles to the center line.)

Technical Pen Parts

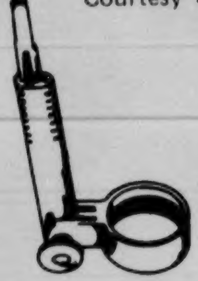

Color - Coded Cap
Spring Seal Mechanism
Tubular Drafting Point
Wire Weight
Air-Pulse Ink-Feed System
Pocket Clip
Metal Cylinder
Air-Tight Seal
Color-Coded Point Tube
Safety Cap
Ink Cartridge
Pen Holder (Barrel)
Point Key

Courtesy of J. S. Staedtler, Inc.

Pen Point

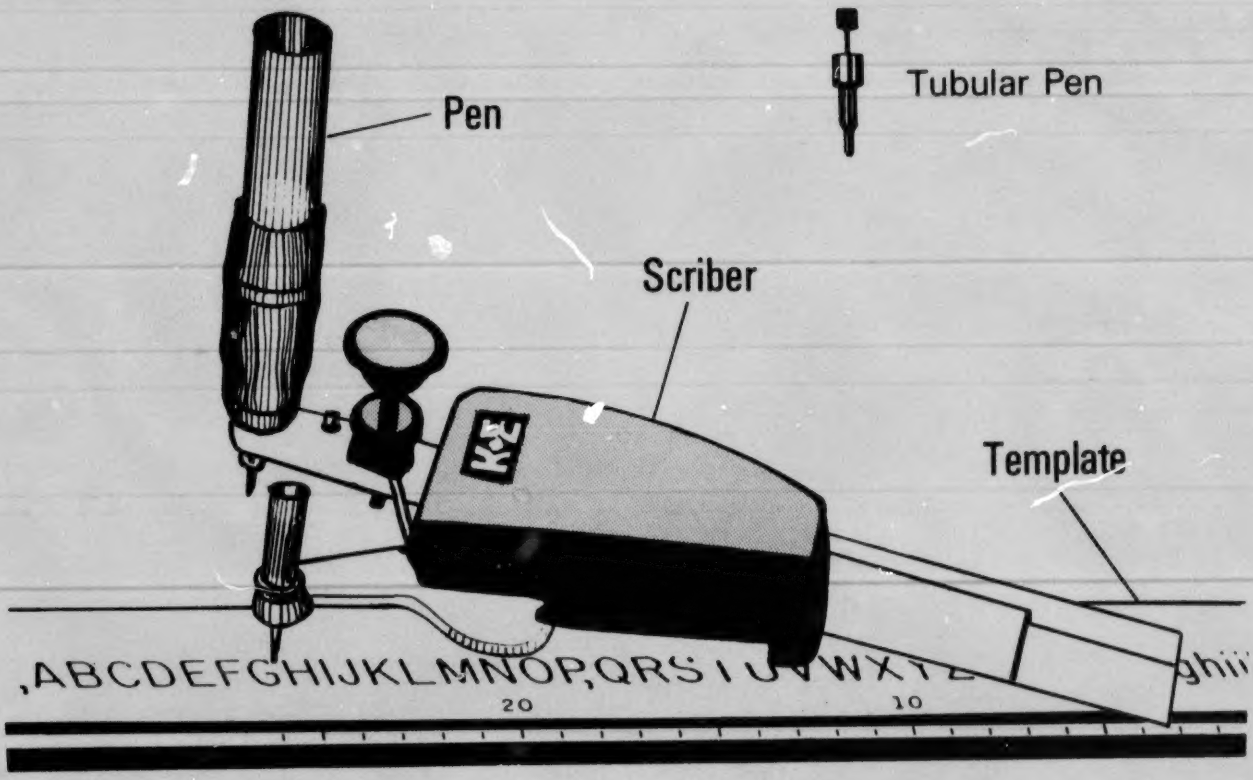

Safety Cap
Wire-Weight
Cleaning Wire
Tube
Air Channel and Vent Hole
Point
Shoulder

Courtesy of Koh-I-Noor Rapidograph, Inc.

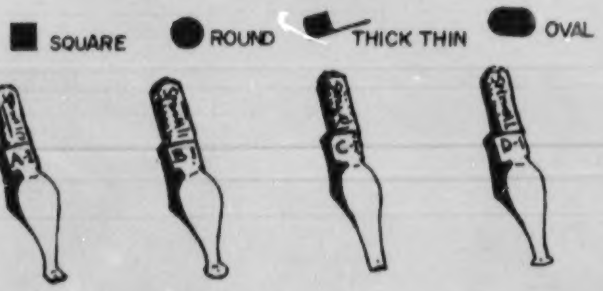


TECHNICAL PEN ATTACHMENT
FOR COMPASS

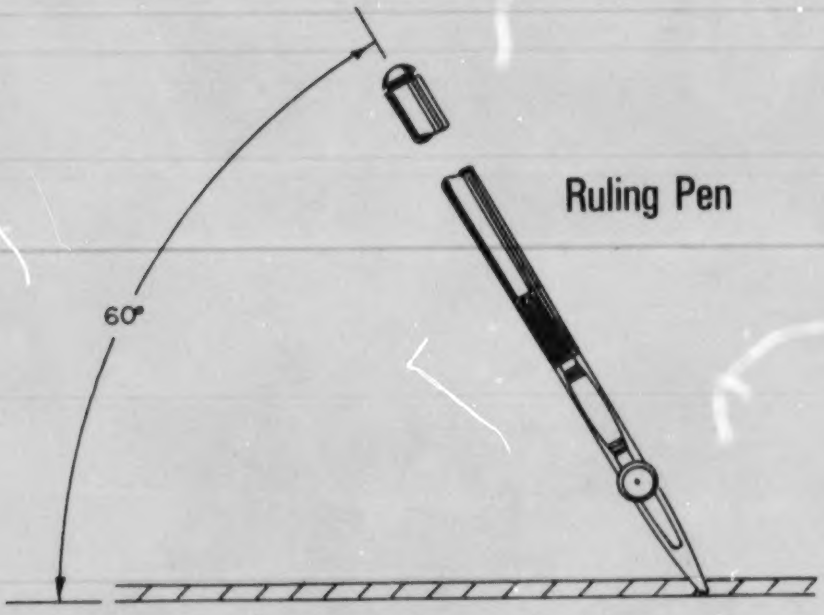
Manual Lettering Device


Pen
Tubular Pen
Scriber
Template
K+E
,ABCDEFGHIJKLMNOP,QRSTUVWXYZ
ghi
20
10

Calligraphic Lettering and Ruling Pens

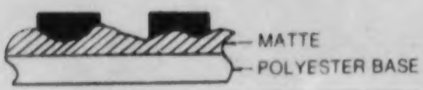

SQUARE
ROUND
THICK THIN
OVAL
A-1
B-1
C-1
D-1

Calligraphic Lettering Pen Nibs

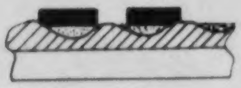


Ruling Pen

FRONT VIEW


MATTE
POLYESTER BASE

GOOD INK ADHESION



POOR INK ADHESION

Visible, Hidden, Center , and Symmetry Lines

Types of Lines | **Width and Character of Lines** | **Applications**

Visible Line

THICK

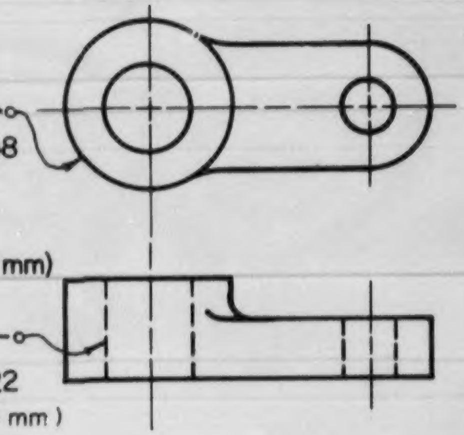
APPROXIMATE WIDTH .030 – .038
(0.75 – 0.96 mm)
PEN 2 (.50 mm)

Hidden Line

1/32 0.3(0.8mm)   1/8 .12(3.2mm)

THIN

APPROXIMATE WIDTH .015 – .022
(0.38 – 0.55mm) PEN 0 (.35 mm)

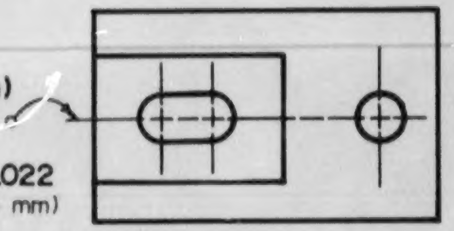


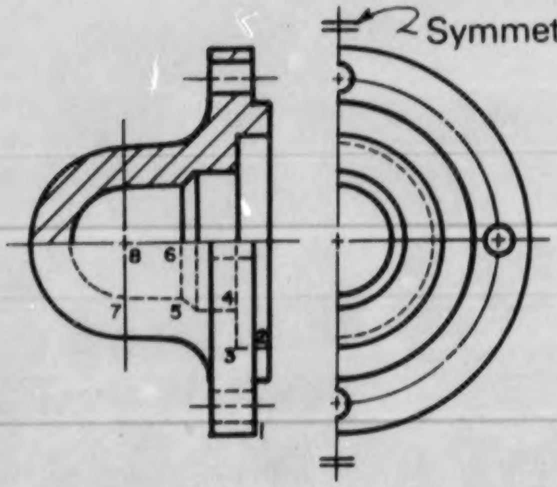
Center Line

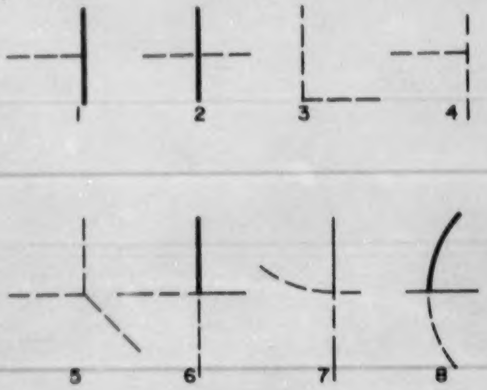
3/4 to 1 1/2 .75–1.50
(19–38mm)   1/8 .12(3.2mm)
1/16 .06 (1.6mm)

THIN

APPROXIMATE WIDTH .015–.022
(0.38–0.55 mm) PEN 0 (.35 mm)



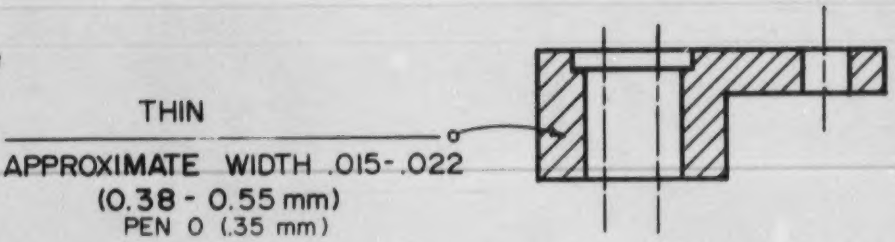




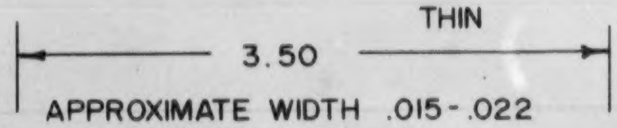
Section, Extension, Dimension, and Leader Lines

Types of Lines **Width and Character of Lines** **Applications**

Section Line

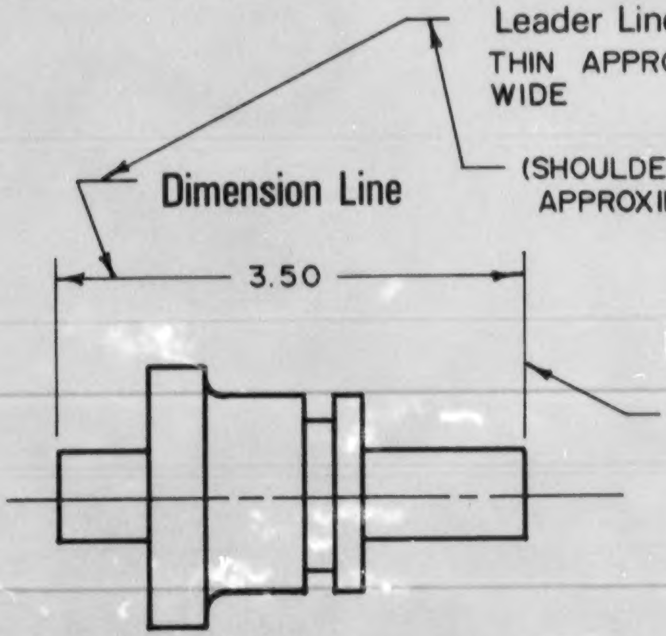

THIN

APPROXIMATE WIDTH .015-.022
(0.38 - 0.55 mm)
PEN 0 (.35 mm)



THIN

APPROXIMATE WIDTH .015 - .022
(0.38 - 0.55 mm)
PEN 0 (.35 mm)



Leader Line

THIN APPROXIMATELY .010
WIDE

(SHOULDER OPTIONAL
APPROXIMATELY 1/4" LONG)

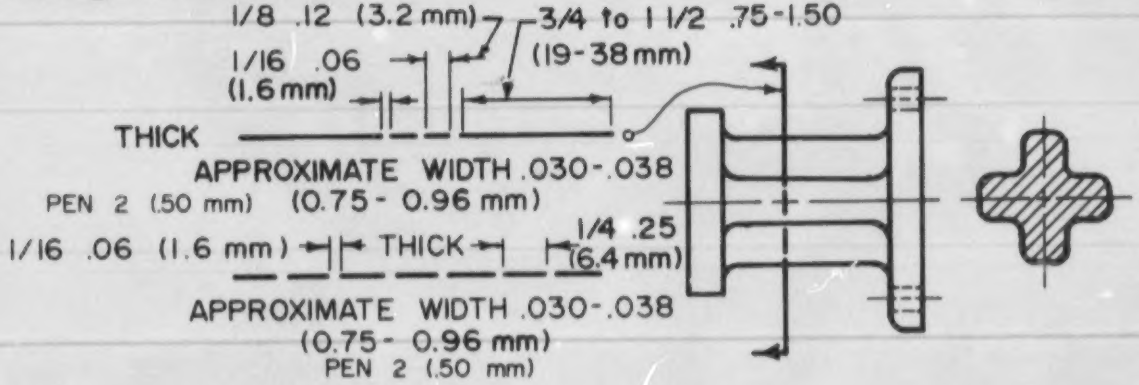
Dimension Line

Extension Line

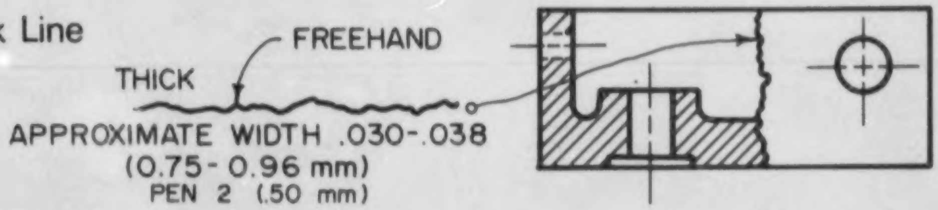
Cutting Plane, Short Break , and Long Break Lines

Types of Lines Width and Character of Lines Applications

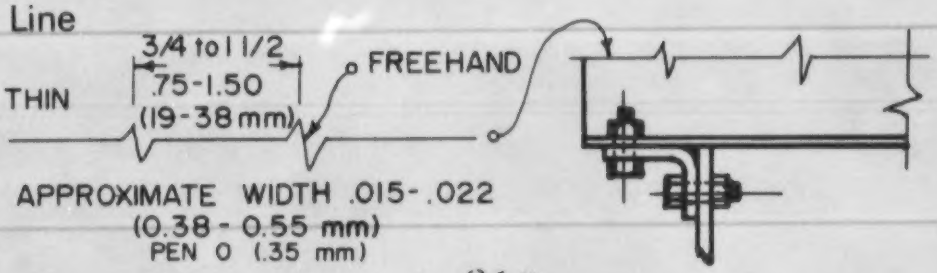
Viewing Plane or Cutting Plane Lines


1/8 .12 (3.2 mm)
3/4 to 1 1/2 .75-1.50 (19-38 mm)
1/16 .06 (1.6 mm)
THICK
APPROXIMATE WIDTH .030-.038
PEN 2 (.50 mm) (0.75 - 0.96 mm)
1/16 .06 (1.6 mm)
THICK
1/4 .25 (6.4 mm)
APPROXIMATE WIDTH .030-.038
(0.75 - 0.96 mm)
PEN 2 (.50 mm)

Short Break Line


FREEHAND
THICK
APPROXIMATE WIDTH .030-.038
(0.75 - 0.96 mm)
PEN 2 (.50 mm)

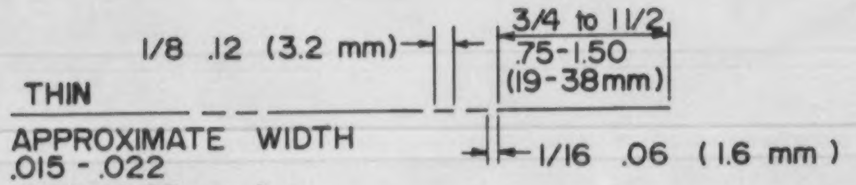
Long Break Line


3/4 to 1 1/2
.75-1.50
(19-38 mm)
FREEHAND
THIN
APPROXIMATE WIDTH .015-.022
(0.38 - 0.55 mm)
PEN 0 (.35 mm)

610

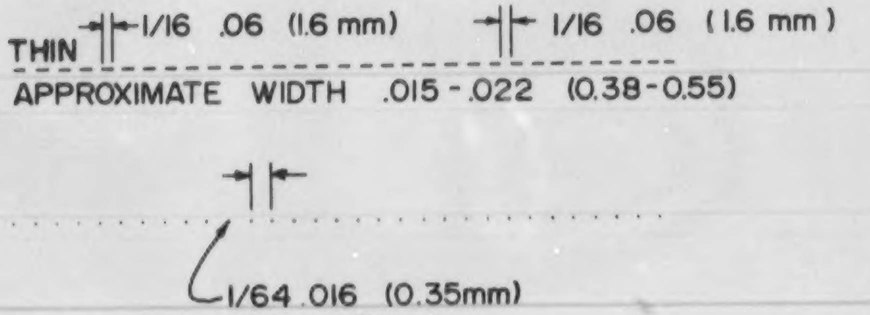
Phantom, Stitch, Chain, and Border Lines

Phantom Line


1/8 .12 (3.2 mm)
3/4 to 1 1/2
.75-1.50
(19-38mm)
THIN
1/16 .06 (1.6 mm)

APPROXIMATE WIDTH
.015 - .022
(0.38 - 0.55 mm)
PEN 0 (.35mm)

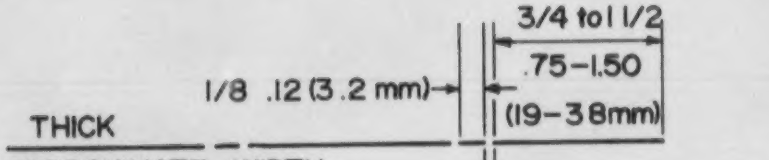
Stitch Line


1/16 .06 (1.6 mm)
1/16 .06 (1.6 mm)
THIN
1/64 .016 (0.35mm)

APPROXIMATE WIDTH .015 - .022 (0.38-0.55)

PEN 0 (.35mm)

Chain Line


3/4 to 1 1/2
.75-1.50
(19-38mm)
1/8 .12 (3.2 mm)
THICK
1/16 .06 (1.6mm)

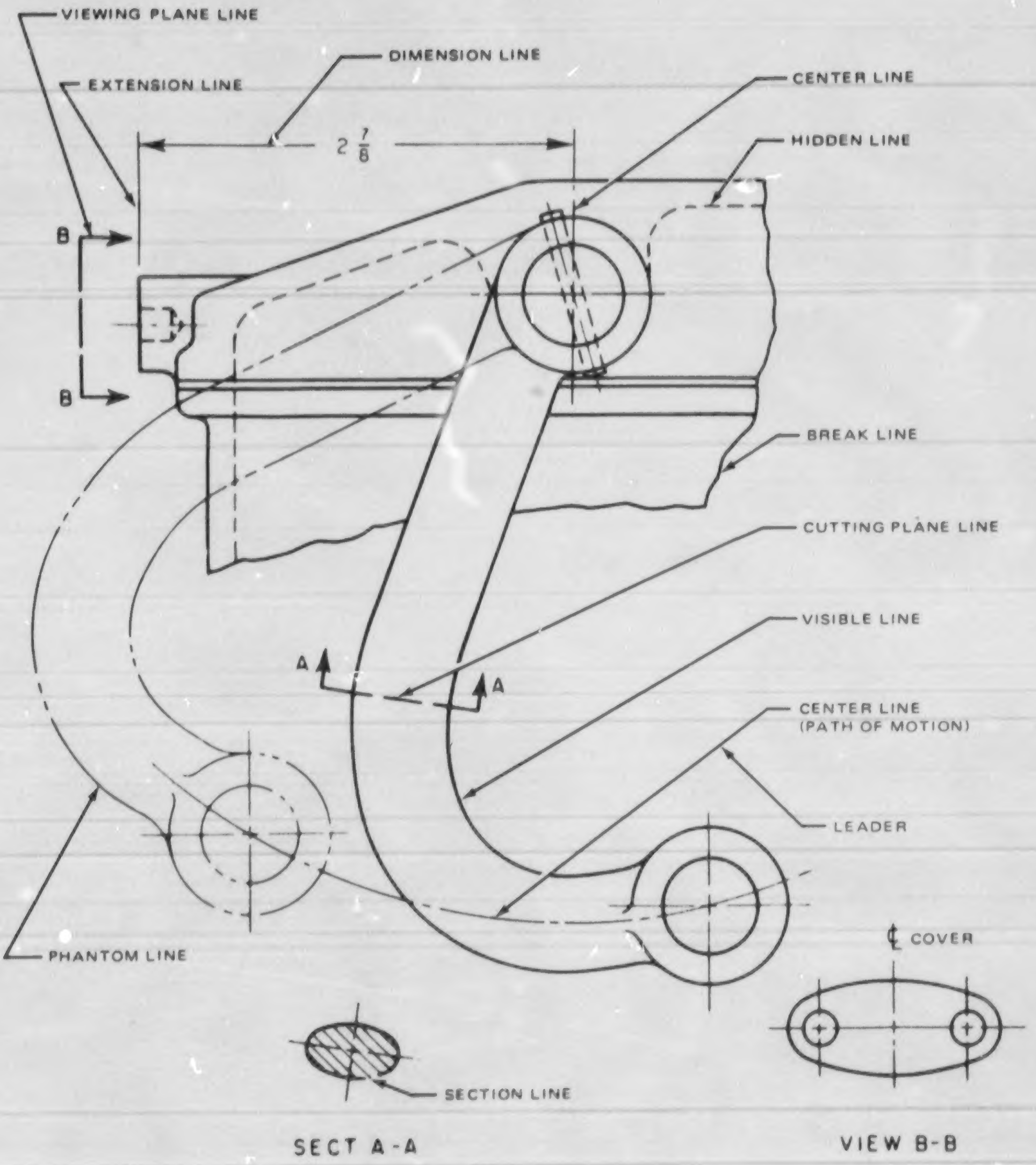
APPROXIMATE WIDTH
.030 - .038
(0.75 - 0.96 mm)
PEN 2 (.50mm)

Border Line

THICK

APPROXIMATE WIDTH .030 – .038
(0.75 – 0.96 mm)
PEN 3 (.80mm)

Line Applications


VIEWING PLANE LINE
DIMENSION LINE
EXTENSION LINE
CENTER LINE
HIDDEN LINE
2 7/8
B
B
BREAK LINE
CUTTING PLANE LINE
VISIBLE LINE
A
A
CENTER LINE (PATH OF MOTION)
LEADER
PHANTOM LINE
℄ COVER
SECTION LINE
SECT A-A
VIEW B-B

INKING TOOLS AND TECHNIQUES
UNIT VIII

ASSIGNMENT SHEET #1--DRAW AND ERASE INK LINES ON VELLUM OR TRACING CLOTH

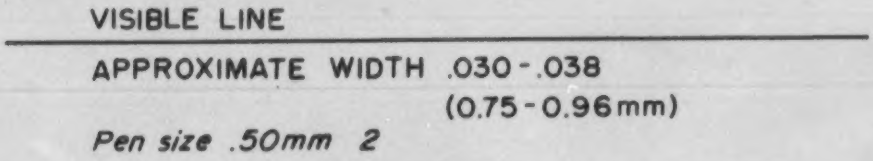
Premise: Ink lines can be drawn and erased on vellum or tracing cloth by using the procedures in the following examples.

Example A: Drawing on vellum or tracing cloth

1. Use ink and media size determined by instructor
2. Decide which side of media to use

   (NOTE: Place felt side of vellum up or dull side of tracing cloth up.)
3. Tape media down on drawing table
4. Clean media if necessary
5. Draw the needed line

   (NOTE: A visible line is used in this example.)



6. Letter the name of the line above the line in vertical upper case lettering using a manual lettering device
7. Letter in below the line the words "Approximate width" and the approximate width figures in English and metric
8. Letter in the recommended pen size in slant lower case lettering

Example B: Erasing on vellum or tracing cloth

1. Check type of eraser to make sure that it is one of the recommended types for use on vellum or tracing cloth
   a. Recommended types for manual use
      1) Plastic embedded with erasing fluid

         (NOTE: These should be stored in air-tight containers.)

ASSIGNMENT SHEET #1

2) Soft, white plastic

3) Soft, white vinyl

4) Soft, pink rubber

(NOTE: Use of this type will be time consuming.)

5) Soft, green

(NOTE: This type effectively removes dirt without smudging and will not weaken newly dried ink lines if properly used.)

b. Recommended types for cord or cordless electric erasing machines

1) Soft, white plastic

2) Soft, white vinyl

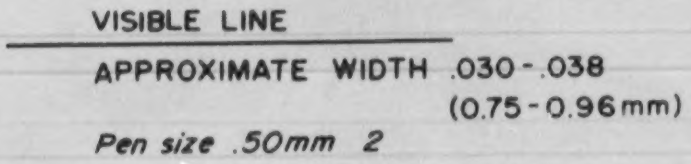
3) Soft, pink rubber

4) Soft, green

(CAUTION: A grey, abrasive eraser strip should not be used because the speed of the eraser coupled with heavy hand pressure will tear a hole in the media surface.)

(NOTE: Because some vellums and tracing cloths are porous, it is wise to experiment to determine the best eraser for the job.)

2. Erase carefully with an electric eraser or an eraser for manual use



(NOTE: In this example only half of the original line drawn in Example A is erased.)

3. Reproduce on blueline print machine to check "ghosting"

DIRECTIONS: Draw and label appropriately the complete alphabet of ink lines. Erase one-half of the drawn lines and reproduce on blueline to check "ghosting." Refer to objective XIV of information sheet for a listing of the alphabet.

INKING TOOLS AND TECHNIQUES
UNIT VIII

ASSIGNMENT SHEET #2--DRAW AND ERASE INK LINES ON POLYESTER FILM

Premise: Ink lines can be drawn and erased on polyester film by using the procedure in the following examples.

Example A: Drawing on polyester film

1. Use ink and polyester film size determined by instructor
2. Place matte side of polyester film up
3. Tape film down on drawing table
4. Clean film if necessary
5. Draw the needed line

   (NOTE: A visible line is used in this example.)

   VISIBLE LINE

   APPROXIMATE WIDTH .030 - .038
   (0.75 - 0.96 mm)

   Pen size .50 mm 2

6. Letter the name of the line above the line in vertical upper case lettering using a manual lettering device
7. Letter in below the line the words "Approximate width" and the approximate width figures in English and metric
8. Letter in the recommended pen size in slant lower case lettering

Example B: Erasing on polyester film

1. Check type of eraser to make sure that it is one of the recommended types for use on polyester film
   a. Recommended types for manual use
      1) Plastic embedded with erasing fluid

         (NOTE: These should be stored in air-tight containers to prevent evaporation.)

      2) Soft, white vinyl

         (NOTE: For best results, moisten the tip.)

ASSIGNMENT SHEET #2

3) Soft, white plastic

4) Soft, pink rubber

5) Soft, green

b. Recommended type for cord or cordless electric erasers--soft, white vinyl

(NOTE: A great deal of caution should be used with electric erasers because the speed of the eraser and heavy hand pressure produce friction and heat which may damage the matte surface. Some manufacturers of polyester film do not recommend the use of an electric eraser.)

(CAUTION: A grey, abrasive eraser strip should never be used because it will totally damage the matte surface.)

2. Erase carefully with a recommended type of eraser or use erasing fluid

a. First, a small amount of erasing fluid is placed on a sponge

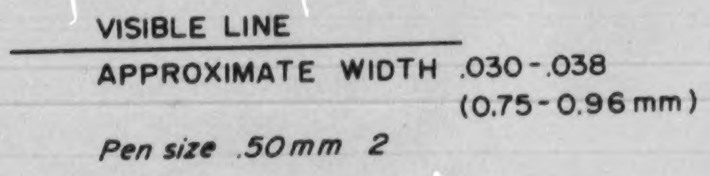
b. Next, a special eraser is dabbed onto the sponge

c. Then, the eraser is used on the film in the standard fashion

Example: Koh-I-Noor Rapidraw eraser kit

(NOTE: For large areas extra strength erasing fluid can be applied to a soft paper towel.)

Example: Koh-I-Noor's Koh-I-Lar



(NOTE: In this example only half of the original line drawn in Example A is erased.)

3. Reproduce on blueline print machine to check "ghosting"

Directions: Draw and label appropriately the complete alphabet of ink lines. Erase one-half of the drawn lines and reproduce on blueline to check "ghosting." Refer to objective XIV of information sheet for a listing of the alphabet.

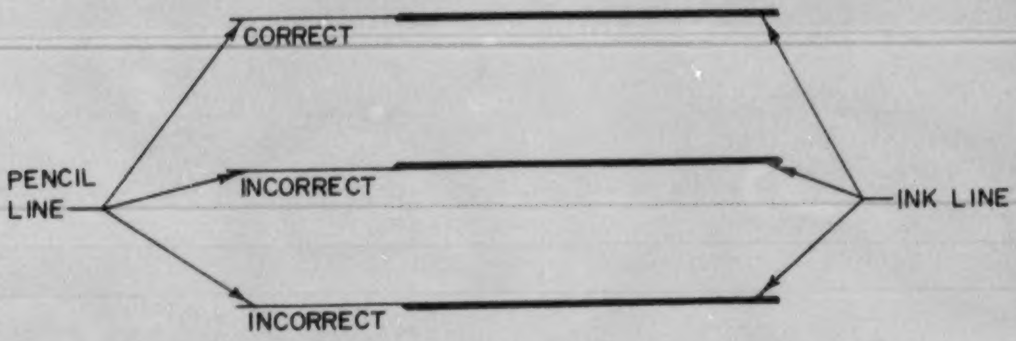
INKING TOOLS AND TECHNIQUES
UNIT VIII

ASSIGNMENT SHEET #3--COMPLETE STEPS IN INKING A DRAWING OR A TRACING

Premise: A drawing or tracing can be inked by using the procedure in the following example.

Example:

1. Ink all arcs and circles first, by centering the ink lines over the pencil lines



2. Ink all straight lines, next, doing the horizontal, then the vertical, and last the inclined lines

   (NOTE: It is far easier to join straight lines to arcs than to join arcs to straight lines.)

3. Ink all extension, dimension, and center lines

   (NOTE: Some drafters prefer to ink center lines before making compass center. This helps to keep ink from running through the holes in the media surface.)

4. Ink in all arrowheads and lettering

   (NOTE: Draw guidelines for lettering directly on the media surface.)

5. Be PATIENT; allow ink to dry before inking adjacent lines

6. If an error is made, wait until it dries; then use an erasing shield to protect line work near the error

Directions: On media and size determined by the instructor, ink all parts of the drawing.

INKING TOOLS AND TECHNIQUES
UNIT VIII

JOB SHEET #1--FILL CLEAN TECHNICAL AND POCKET MODEL PENS

I. Tools and materials

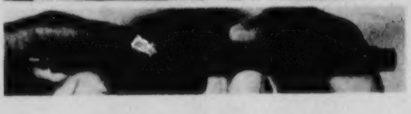
- A. Clean technical pen
- B. Clean pocket model technical pen
- C. Ink filler bottle
- D. Lint-free cloth or tissue

II. Procedure

A. Fill a clean technical pen

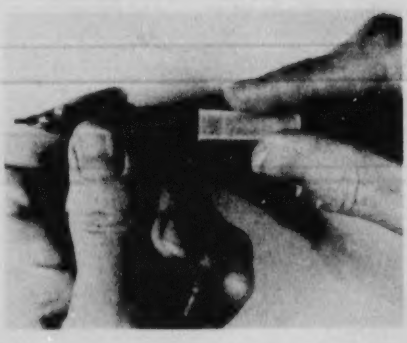
1. Remove cap

2. Grip clamp ring and unscrew holder (barrel)

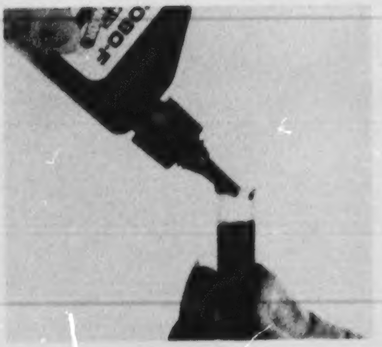


3. Using light finger pressure, unscrew and remove clamp rings

4. Hold pen point upright and pull off ink cartridge



5. Hold cartridge at a slight tilt while filling cartridge, then turn cartridge upright



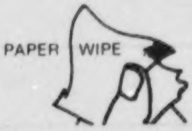
6. Fill cartridge from ink filler bottle to a line 1/4" from the top, but not past the 1/4" line

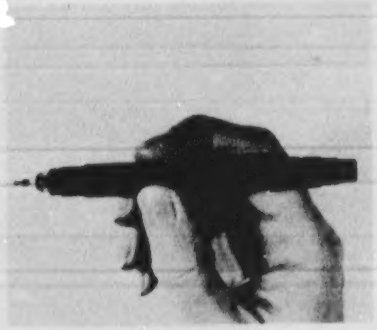
   (NOTE: If permanent ink should spill on clothing, wash area immediately with soap and cold water.)

7. Keep cartridge upright and reassemble pen

8. Press filled cartridge slowly onto pen body to prevent residual ink from entering air channel

9. After assembly, wipe off excess ink with a lint-free cloth or tissue





10. With cap off, gently shake pen horizontally several times to start ink flow

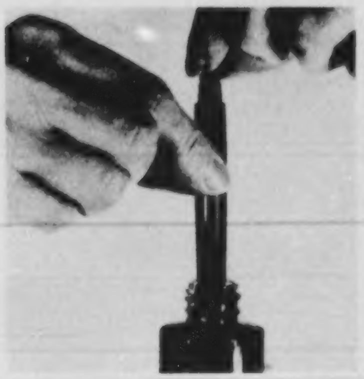
    (NOTE: Always keep cartridge more than half full of ink for proper flow.)

B. Fill a clean pocket model technical pen

1. Remove cap

2. Unscrew and remove filler knob cap

JOB SHEET #1

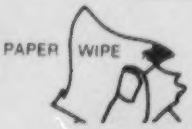


3. Submerge entire pen point into ink and turn filler knob counter-clockwise until resistance is felt and threads are exposed

4. Turn knob clockwise until resistance is felt (NOTE: Pen barrel is now 3/4 full.)

5. With the point still in the ink, again turn knob counter-clockwise, then clockwise to completely fill barrel

6. Wipe off excess ink with lint-free cloth or tissue



7. With cap off gently shake pen horizontally several times to start ink flow

   (NOTE: Always keep barrel more than half full of ink for proper flow.)

All illustrations for this job sheet courtesy of Koh-I-Noor Rapidograph, Inc.

INKING TOOLS AND TECHNIQUES
UNIT VIII

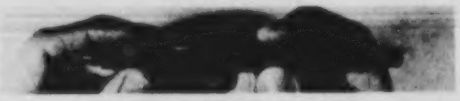
JOB SHEET #2--REFILL A TECHNICAL PEN

I. Tools and materials

- A. Partially filled technical pen
- B. Ink filler bottle
- C. Lint-free cloth or tissue

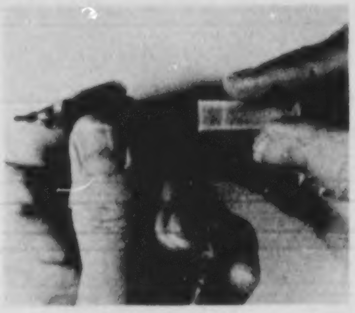
II. Procedure

A. Grip clamp ring and unscrew pen holder (barrel)



B. Using light finger pressure, unscrew and remove clamp ring

C. Hold pen point upright and pull off ink cartridge



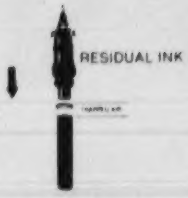
D. Lightly tap the rear portion of the pen body on absorbent paper to remove excess ink

E. Hold cartridge at a slight tilt while refilling, then turn cartridge upright

JOB SHEET #2

F. Fill cartridge from ink filler bottle to a line 1/4" from the top, but not past the 1/4" line

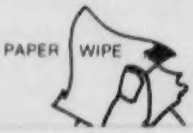
(NOTE: If permanent ink should spill on clothing, wash area immediately with soap and cold water.)

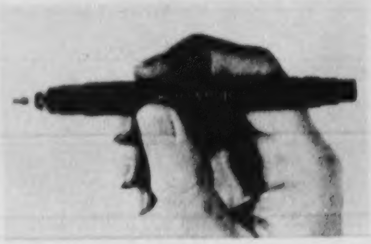


G. Keep cartridge upright and reassemble pen

H. Press filled cartridge slowly onto pen body to prevent residual ink from entering air channel

I. After assembly, wipe off excess ink with a lint-free cloth or tissue





J. With cap off gently shake pen horizontally several times to start ink flow

(NOTE: Always keep cartridge more than half full of ink for proper flow.)

All illustrations for this job sheet courtesy of Koh-I-Noor Rapidograph, Inc.

INKING TOOLS AND TECHNIQUES
UNIT VIII

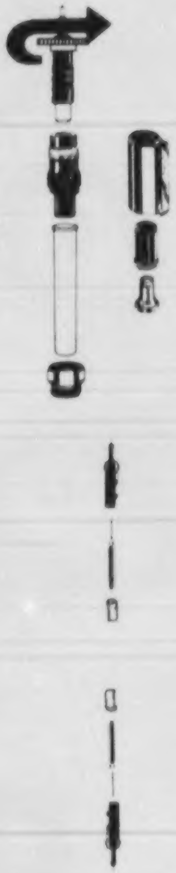
JOB SHEET #3--CLEAN TECHNICAL AND POCKET MODEL PENS USING THE STANDARD CLEANING METHOD

I. Tools and materials

- A. Technical pen
- B. Pocket model technical pen
- C. Lint-free cloth or tissue
- D. Cleaning solution

II. Procedure

A. Clean a technical pen



1. Remove ink cartridge

2. Pour out ink and flush out excess ink with water

3. Remove the nib from its holder with a key

   (NOTE: Some technical pens have the key built into the pen holder.)

   (CAUTION: Nib disassembly is not recommended unless absolutely necessary, and a .30 mm #00 nib or smaller should never be disassembled.)

4. Remove nib safety cap and hold nib point up to allow the wire-weight to fall out into hand

   (CAUTION: NEVER PULL a wire-weight to remove it.)

5. Carefully clean the wire-weight and the nib

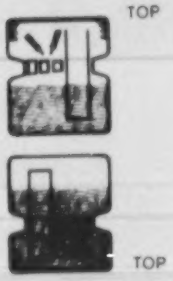
6. Hold nib point down and carefully drop the wire-weight into the writing tube of the nib

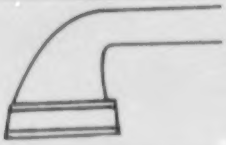
JOB SHEET #3

7. Jiggle the pen carefully to allow the wire-weight to fall back into place, but DO NOT FORCE the wire-weight back into place

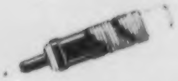
8. Replace nib safety cap

9. Soak cartridge and entire nib in pen cleaner until the dried ink dissolves (overnight if necessary)

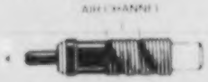




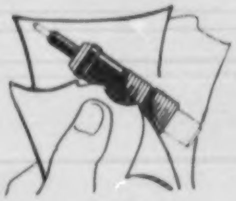
10. Remove cleaning solution from all pen parts by rinsing with warm water



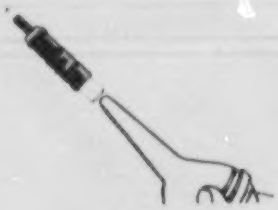
11. Clean pen body and cap by flushing with warm water



12. Check air channel and vent hole to make sure they are thoroughly clean



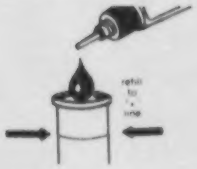
13. Dry all parts thoroughly with a paper towel



(NOTE: A bellows or ear syringe is handy to use for air drying the nib.)

JOB SHEET #3

14. If pen is to be used in the near future, use standard procedure to refill the ink cartridge

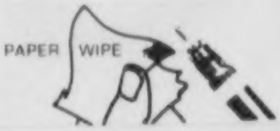


15. If pen will not be used for an extended period of time, fill the ink cartridge with cleaning solution

16. Hold cartridge upright and reassemble pen

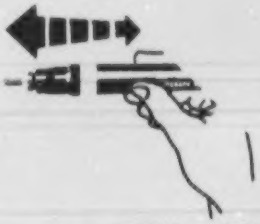
17. Press filled cartridge slowly into the body of the pen to prevent residual ink from entering the air channel

18. After assembly, wipe off excess ink with a lint-free cloth or tissue



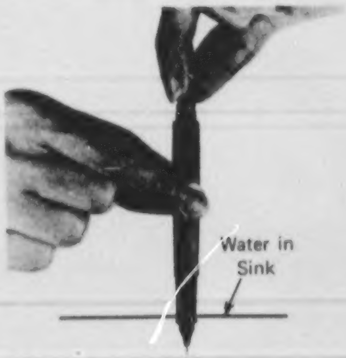
19. With cap off, gently shake pen horizontally several times to start ink flow

    (NOTE: Pens in normal use should be cleaned on a regular basis, and pens in use should always have cartridges more than half full of ink to insure ink flow.)



B. Clean a pocket model technical pen

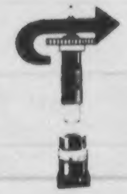
   1. Expel ink by turning filler knob counter-clockwise



JOB SHEET #3

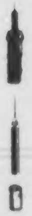
2. Remove nib with nib key

   (CAUTION: Nib disassembly is not recommended unless absolutely necessary and a nib .30 mm #00 or smaller should never be disassembled.)



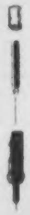
3. Remove safety cap and hold point up to allow wire-weight to fall into hand

   (CAUTION: NEVER PULL wire-weight to remove it.



4. Carefully clean wire-weight and nib

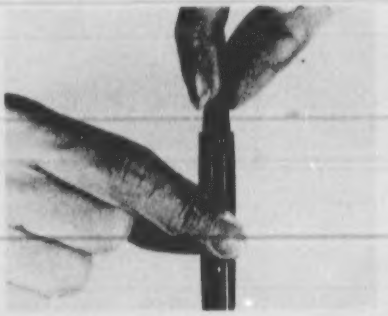
5. Hold nib point down and carefully drop wire-weight into writing tube of nib



6. Jiggle pen carefully to allow wire-weight to fall back into place, but do not force the wire-weight back into place

7. Replace safety cap

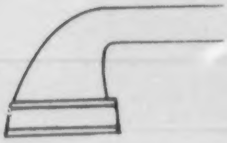
8. Turn filler knob clockwise as far as it goes



9. Hold barrel upright and fill half-way with liquid pen cleaner

JOB SHEET #3

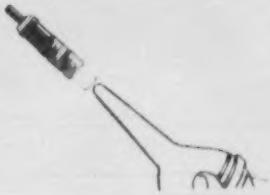
10. With thumb over open end, gently shake barrel horizontally, then flush with warm water



11. Clean cap by flushing with warm water

12. Air dry all parts thoroughly with bellows or ear syringe before reassembling pen and refilling with ink

(NOTE: If the pen must be used before it is completely air dried, flush ink through the reassembled point and barrel by filling and expelling ink several times before the final fill; under no circumstances should the pen be used until all cleaning fluid and water have been removed in this fashion.)



All illustrations for this job sheet courtesy of Koh-I-Noor Rapidograph, Inc.

INKING TOOLS AND TECHNIQUES
UNIT VIII

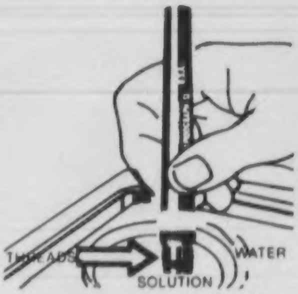
JOB SHEET #4--CLEAN A TECHNICAL PEN WITH AN ULTRASONIC CLEANER

I. Tools and materials

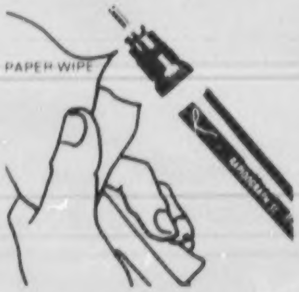
- A. Technical pen
- B. Ultrasonic cleaner
- C. Ultrasonic cleaning fluid
- D. Lint-free cloth or tissue

II. Procedure

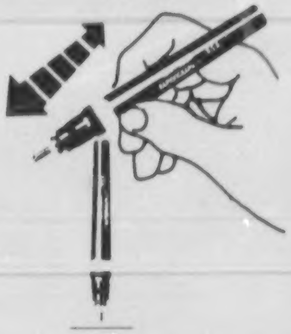
A. Without removing ink, submerge pen up to cap threads in cleaning solution for 30 seconds



B. Blot the cleaning solution from the air channel with a paper wipe



C. With the technical pen, draw on a scrap piece of vellum or other media material to remove the cleaning solution from the writing tube



(NOTE: This preventative maintenance should be performed daily after each work session, if the pen was used; if the pen point is extremely dirty, follow the standard cleaning method.)

(CAUTION: Do not submerge the entire pen point in the ultrasonic cleaner for an extended time period or damage to the pen point and ultrasonic cleaner will result.)

All illustrations for this job sheet courtesy of Koh-I-Noor Rapidograph, Inc.

INKING TOOLS AND TECHNIQUES
UNIT VIII

TEST

NAME_______________________________

1. Match the terms on the right with their correct definitions.

_____a. Does not allow light to pass through

_____b. Has the property of transmitting or allowing light to pass through

_____c. Tracing paper which has been treated with a transparentizing agent which normally consists of waxes, oils, and similar substances

_____d. Fabric that has undergone a transparentizing process and is sized with a type of starch compound or plastic to provide a good working surface for pencil or ink

_____e. A tough translucent plastic drafting medium, usually made by bonding a matte surface to one or both sides of a clear polyester sheet

_____f. Lacking or deprived of gloss or lustre

_____g. A liquid composed mainly of carbon in colloidal suspension and gum

_____h. Usually consists basically of a pen holder, ink cartridge, a point, and a cap

_____i. Pen point

_____j. Device which consists of a shoulder of metal or plastic in a cylinder placed in a plastic color-coded point tube with an air channel and vent hole, a wire-weight, and a wire-weight safety cap

_____k. Firm or steady attachment

_____l. Capable of forming an homogenous mixture that does not separate or alter by chemical interaction with each individual substance or material

1. Manual lettering device
2. Ink
3. Dogboning
4. Pen point
5. Vellum
6. Technical pen
7. Nib
8. Calligraphic lettering pen
9. Ultrasonic pen cleaner
10. Ghosting
11. Compass adapter
12. Tracing cloth
13. Watermark
14. Opaque
15. Wire side
16. Polyester drafting film
17. Ink triangle
18. Transparent
19. Compatible
20. Adhesion
21. Matte
22. Ink riser
23. Feathering
24. Tubular pen
25. Felt side

______m. Occurs when an ink line spreads in an uneven fashion; usually due to drawing on the wire side of the vellum

______n. Side of the paper that is down when paper goes through a paper-making machine

______o. Side of the paper that is up when paper goes through a paper-making machine

______p. A distinctive mark or design produced by the raised pattern of the dandy roll on the wet sheet; usually used as a trademark

______q. When ink lines spread out at the beginning and end of a line

______r. Device which uses millions of microscopic bubbles to clean the point of a technical pen

______s. A straight-edged three sided device whose total angles equal 180° made of thin, flat plastic, or metal with acute angles of 45° or angles of 30° and 60° with one or both sides bevelled so that ink will not run under triangle

______t. Thin plastic template placed under a template or triangle so that ink will not run under template or triangle

______u. A device for technical pens to hold the pen in the proper position in a compass

______v. An instrument consisting of a lettering template, scriber, and a tubular pen or a technical pen made for scriber use

______w. Pen device that fits into a scriber; consists of a pen point and a cleaning pin

______x. A fast lettering, freehand drawing pen with an ink reservoir; it is used for calligraphic handwriting by card writers, commercial artists, drafters, and letterers

______y. A smudged area or image on a reproduction copy of a drawing caused by a damaged surface due to erasing or mishandling of the original

2. Select types of drawing inks by placing an "X" in the appropriate blanks.

_____a. Transparent colors

_____b. Stamp pad ink

_____c. Tempera ink

_____d. Washable, opaque

_____e. Permanent or waterproof black

_____f. Opaque colors

3. Select quality requirements of good drawing ink by placing an "X" in the appropriate blanks.

_____a. Must be flowing

_____b. Must be transparent

_____c. Must have good adhesion to the media surface

_____d. Must be slow-drying

_____e. Must dry to sufficient hardness to resist chipping and flaking

_____f. Must be able to be erased easily at any later date without severe damage to the media surface

4. Select true statements concerning the properties and performance of drawing inks by placing an "X" in the appropriate blanks.

_____a. During manufacturing, drawing inks undergo many chemical and physical tests

_____b. Salts and other impurities do not seriously affect the ink mixture

_____c. The solvents in ink will rapidly evaporate and result in thickened ink unless the bottle of ink is capped after each use

_____d. Drawing materials that are not chemically compatible have no influence on the quality of the ink line

_____e. In recent years manufacturers of drawing ink have started using latex as a binder to replace shellac; this causes the ink to be waterproof after curing and produces an extremely dense black ink line

_____f. Ballpoint pens may be used for hand drawing when accuracy is necessary

5. List three types of pen points.

a. ______________________________

b. ______________________________

c. ______________________________

6. Select true statements concerning the ways to properly use and care for technical pens by placing an "X" in the appropriate blanks.

_____a. The proper way to hold the technical pen is horizontally, with a very heavy touch

_____b. While drawing, always push the technical pen; never pull it

_____c. The air channel allows air to enter the ink cartridge in order to replace the ink that has been used

_____d. The technical pen may be left uncapped when not in use for short periods of time

_____e. The wire-weight should always be removed during cleaning

_____f. When a technical pen is to be stored for an extended period of time, it should be cleaned well and filled with pen cleaning solution

_____g. Before using a pen that has been stored a long time, flush it with warm water, thoroughly dry it, and refill it with ink

7. Complete the following statements concerning procedures for matching microfilmed drawings.

a. When reducing a microfilmed drawing to the next lower size, use a pen point ______________________ than was used on the original drawing

b. When enlarging a microfilm drawing to the next larger size, use a pen point ______________________ than was used on the original drawing

8. List two ways to properly use technical pens with programmed automated digital plotters.

a. ______________________________

____

b. ______________________________

____

9. Select true statements concerning precautions when using ink on vellum or tracing cloth by placing an "X" in the appropriate blanks.

_____a. Be sure wire side of vellum is up

_____b. Be sure shiny side of tracing cloth is up

_____c. Before putting any linework on vellum or tracing cloth, they should be cleaned and the cleaning material removed

_____d. Ink is easy to remove from vellum or tracing cloth because they are non-porous materials

_____e. When linework is erased, it may leave a "ghosting" effect when reproduced, so erase with care

10. Select true statements concerning characteristics of polyester film and procedures for using ink on polyester film by placing an "X" in the appropriate blanks.

_____a. If the polyester film is matte on only one side, place the shiny side up for drawing

_____b. Before putting any linework on polyester film, the film should be wiped clean with a moist paper towel

_____c. Ink is difficult to remove from polyester film

_____d. Ink lines will flake or chip off the drafting film when some foreign materials are present between the ink line and the polyester film

_____e. The matte coating is applied to polyester film so a line will adhere securely to the surface

_____f. For hand drafting, the most common thickness used is 15 mil

11. Select factors that contribute to making a line heavier with a ruling pen by placing an "X" in the appropriate blanks.

_____a. Moving the pen too fast

_____b. Overfilling the pen

_____c. Nibs too sharp

_____d. Leaning the pen toward the paper

_____e. Hard working surface

_____f. Dried ink particles caked on the nibs

12. Select factors that contribute to making a line thinner with a ruling pen by placing an "X" in the appropriate blanks.

______a. Moving the pen too fast

______b. Overfilling the pen

______c. Dull nibs

______d. Pen held to nearly vertical

______e. Hard working surface

______f. Dried ink particles caked on the nibs

13. Discuss useful tips for working with ink.

____

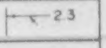
____

____

____

____

14. Complete the following chart of the alphabet of ink lines. Be sure to fill in every blank line.

Name of line	Dimension	Approximate Width in in.	Recommended Pen size and number	Figure
Visible line		030 038	50 mm 2	————
	Thin	015 022	35 mm 0	- - - - - - - -
Center line (Symmetry line)	Thin	015 022	35 mm 0	—— – ——
Section line	Thin	015 022	35 mm 0	
	Thin	015 022	35 mm 0	 2.3
Extension line	Thin	015 022	35 mm 0	2.3
Leader line	Thin	015 022	35 mm 0	
Viewing plane or Cutting plane		030 038	50 mm 2	—— - - ——
Short break line	Thick	030 038	50 mm 2	〰〰
Long break line	Thin	015 022	35 mm 0	
Phantom line or Adjacent part line	Thin	015 022	35 mm 0	—— — — ——
	Thin	015 022	35 mm 0	- - - - - - -
Chain line	Thick	030 038	50 mm 2	—— - ——
Border line	Thick	038+	80 mm 3	━━━━

15. Demonstrate the ability to:
    a. Draw and erase ink lines on vellum or tracing cloth.
    b. Draw and erase ink lines on polyester film.
    c. Complete steps in inking a drawing or a tracing.
    d. Fill clean technical and pocket model pens.
    e. Refill a technical pen.
    f. Clean technical and pocket model pens using the standard cleaning method.
    g. Clean a technical pen with an ultrasonic cleaner.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

INKING TOOLS AND TECHNIQUES
UNIT VIII

ANSWERS TO TEST

1. a. 14
   b. 18
   c. 5
   d. 12
   e. 16
   f. 21
   g. 2
   h. 6
   i. 7
   j. 4
   k. 20
   l. 19
   m. 23
   n. 15
   o. 25
   p. 13
   q. 3
   r. 9
   s. 17
   t. 22
   u. 11
   v. 1
   w. 24
   x. 8
   y. 10

2. a, d, e, f

3. a, c, e, f

4. a, c, e

5. a. Stainless steel
   b. Jewel
   c. Tungsten-Carbide

6. c, f, g

7. a. One size smaller
   b. One size larger

8. Any two of the following:

   a. Plotter pen points require instantaneous start-up and shut-off of ink flow

   b. Jewel and tungsten points are usually recommended for automatic plotter used on polyester film

   c. The wire-weight should never be removed during cleaning, especially in sizes .30 mm #00 or smaller

   d. The average speed for hand drafting is 4 inches per second, but some automated plotters draw as fast as 40 inches per second, and this requires exacting pen performance

9. c, e

10. b, d, e

11. b, d, f

12. a, d, e

13. Discussion should include:

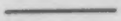
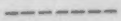
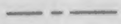
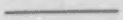
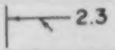
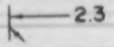
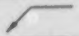
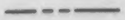
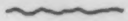
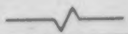
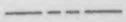
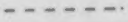
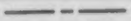
    a. If an ink triangle is not available, use pennies or drafting tape on one side of the triangle to raise the triangle off the paper

    b. If an ink riser is not available, place another triangle under the one being used to prevent ink from flowing under the triangle

    c. Periodically check the technical pen for leaking around the tip to prevent your hands from smearing the drawing; also check the tip for a drop of ink on the tip

    d. If an ink riser is not available, place the template over a triangle to raise the template off the paper; the triangle gives good support and adequate clearance to prevent ink from running under template

14.

Name of line	Dimension	Approximate Width in in.	Recommended Pen size and number	Figure
Visible line	Thick	.030-.038	.50 mm 2	
Hidden line	Thin	.015-.022	.35 mm 0	
Center line (Symmetry line)	Thin	.015-.022	.35 mm 0	
Section line	Thin	.015-.022	.35 mm 0	
Dimension line	Thin	.015-.022	.35 mm 0	
Extension line	Thin	.015-.022	.35 mm 0	
Leader line	Thin	.015-.022	.35 mm 0	
Viewing plane or Cutting plane	Thick	.030-.038	.50 mm 2	
Short break line	Thick	.030-.038	.50 mm 2	
Long break line	Thin	.015-.022	.35 mm 0	
Phantom line or Adjacent part line	Thin	.015-.022	.35 mm 0	
Stitch line	Thin	.015-.022	.35 mm 0	
Chain line	Thick	.030-.038	.50 mm 2	
Border line	Thick	.038+	.80 mm 3	

15. Evaluated to the satisfaction of the instructor

AXONOMETRICS
UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify isometric axis line positions and plane surfaces on isometric drawings. The student should also be able to center in a working space, box in, construct angles, construct circles, measure in, and dimension an isometric drawing. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to axonometrics with their correct definitions.
2. List three types of axonometric drawings.
3. Identify positions used as axis lines for isometric drawings.
4. Identify plane surfaces on isometrics.
5. Select true statements concerning rules in constructing an isometric drawing.
6. Match common errors made in isometric drawing with their correct drawings.
7. Distinguish between the advantages and disadvantages of isometric drawing.
8. Select methods of dimensioning an isometric.
9. Select true statements concerning rules in dimensioning an isometric drawing.
10. Demonstrate the ability to:
    - a. Sketch an isometric drawing.
    - [illegible] Sketch isometric circles
    - c. Construct an axonometric drawing by box method.
    - d. Construct angles on an isometric.
    - e. Construct isometric circles and arcs.
    - f. Construct isometric curves by coordinates.

   g. Measure in isometric by offsets.

   h. Construct an isometric in the center of a drawing media.

11. Construct isometric drawings of various objects.

AXONOMETRICS
UNIT IX

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Show filmstrips or films which cover the fundamentals of isometric drawings. Refer to additional material for suggested teaching aids.

VII. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  A. Objective sheet
  B. Information sheet
  C. Transparency masters
    1. TM 1--Types of Axonometric Drawings
    2. TM 2--Positions of Isometric Axis Lines
    3. TM 3--Surfaces on an Isometric
    4. TM 4--Errors on Isometrics
    5. TM 5--Errors on Isometrics (Continued)
    6. TM 6--Methods of Dimensioning Isometrics
    7. TM 7--Dimensioning Procedures
  D. Assignment sheets
    1. Assignment Sheet #1--Sketch an Isometric Drawing
    2. Assignment Sheet #2--Sketch Isometric Circles

3. Assignment Sheet #3--Construct an Axonometric Drawing by Box Method
4. Assignment Sheet #4--Construct Angles on an Isometric
5. Assignment Sheet #5--Construct Isometric Circles and Arcs
6. Assignment Sheet #6--Construct Isometric Curves by Coordinates
7. Assignment Sheet #7--Measure in Isometric by Offsets
8. Assignment Sheet #8--Construct an Isometric in the Center of a Drawing Media

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Giesecke, Frederick E., et al. *Technical Drawing.* New York 10022: Macmillan Publishing Co., Inc., 1980.

B. Brown, Walter C. *Drafting for Industry*. South Holland, Illinois 60473: Goodheart-Willcox Co., Inc., 1974.

C. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

D. Dygdon, John Thomas and Henry Cecil Spencer. *Basic Technical Drawing.* New York: Macmillan Publishing Co., Inc., 1968.

E. Spence, William P. *Drafting Technology and Practice.* Peoria, Illinois 61614: Chas. A. Bennett Co., Inc., 1973.

III. Additional materials:

A. Filmstrip/cassette--"Drafting-Series I and II." Doubleday Multimedia; 1371 Reynolds Avenue; Santa Ana, CA 92705.

B. Transparencies--"The ABC's of Drafting." DCA Educational Products: DCA Incorporated, Warrington, PA 18976.

C. Filmstrip/cassette--"Drafting/Mechanical Drawing." Prentice Hall Media; Serv Code VD354; 150 White Plaines Road; Tarrytown, NY 10591.

AXONOMETRICS
UNIT IX

INFORMATION SHEET

I. Terms and definitions

A. Axonometric--A type of pictorial with each of the three planes and axes at any angle and not equal to 90°

B. Pictorial--Suggesting a picture or mental image

(NOTE: Three types of pictorials are axonometric, oblique, and perspective.)

C. Isometric--A type of axonometric drawing with each of the three planes and axes equal to each other

D. Dimetric--A type of axonometric drawing with two planes on equal axes to each other and a third plane of a different angle

E. Trimetric--A type of axonometric drawing with all three planes and axes not equal to each other

F. Foreshortened--To appear shorter to the eye than it actually is

G. Axis lines--The lines used to represent surfaces or planes coming together

H. Projection--To extend from one point to another

I. Isometric lines--The lines that run parallel to the isometric axis lines

J. Non-isometric lines--The lines that do not run parallel to the isometric axis lines

K. Ellipse--A foreshortened circle with a major and minor diameter

L. Offset coordinates--A method of locating a point from a horizontal and a vertical line

II. Types of axonometric drawings (Transparency 1)

A. Isometric

B. Dimetric

C. Trimetric

INFORMATION SHEET

III. Positions used as axis lines for isometric drawings (Transparency 2)

A. Top

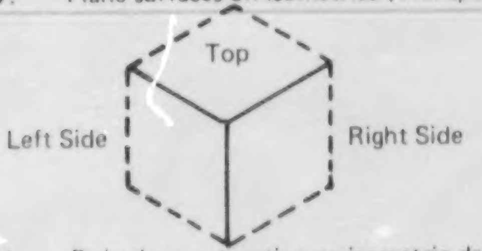
(NOTE: The top position is most commonly used.)

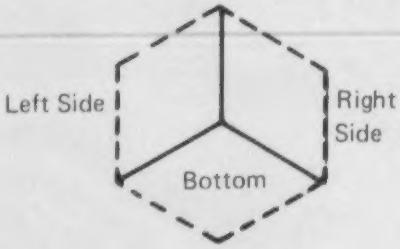
B. Bottom

C. Right side

D. Left side

IV. Plane surfaces on isometrics (Transparency 3)





V. Rules in constructing an isometric drawing

A. All measurements are made parallel to the main edges of the isometric axis lines

B. Angles are measured by coordinate offsets and cannot be transferred in degrees

C. Hidden lines are omitted in isometric drawings if possible

D. A drawing should be centered in the work space and boxed in before adding details

E. If isometric templates are not available, then approximate ellipses must be constructed to represent circles

F. Always block in a circle before constructing its arcs

G. The sight direction that best represents the object should be used for the isometric position

H. If lines are parallel in two successive orthographic views, they are parallel in isometric views

VI. Common errors made in isometric drawing (Transparencies 4 and 5)

A. Object viewed from wrong direction

B. Circle arcs not tangent to each other

INFORMATION SHEET

C. Ellipses not in proper plane

D. Tangent lines missing from circles and arcs

E. Rear ellipse of a hole missing

F. Lines of isometric omitted

G. Angles not measured correctly

H. Dimensions not measured parallel to isometric axis lines

VII. Advantages and disadvantages of isometric drawing

A. Advantages

1. Easy to construct
2. Three sides of an object may be shown in one view
3. Circles are not very distorted

B. Disadvantages

1. Long objects appear distorted
2. Symmetrical type drawing causes some lines to meet or overlap, confusing the viewer

VIII. Methods of dimensioning an isometric (Transparency 6)

A. Aligned

B. Unidirectional

IX. Rules in dimensioning an isometric drawing (Transparencies 6 and 7)

A. Dimensions must all be put in by the aligned method or the unidirectional method

B. Use guidelines for all notes

C. Dimension and extension lines should be parallel to the plane being dimensioned

D. Keep dimensions off object if possible

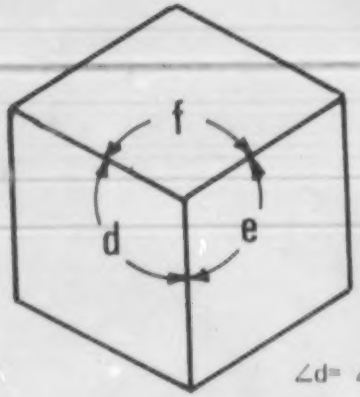
E. Dimensions should all be to visible surfaces if possible

F. Dimension size of holes with notes and leaders

G. Keep dimension lines evenly spaced and not crowding the drawing

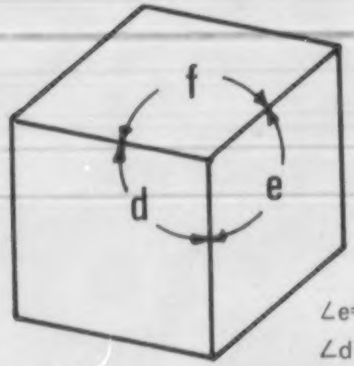
H. Notes should be parallel to the horizontal plane

Types of Axonometric Drawings



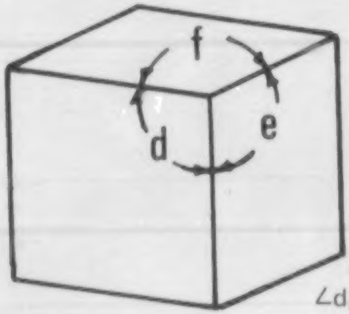
∠d= ∠e= ∠f= 120°

Isometric



∠e= ∠f
∠d not =

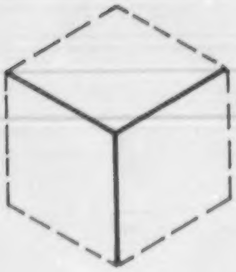
Diametric



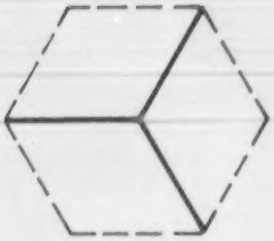
∠d, ∠e, ∠f are not =

Trimetric

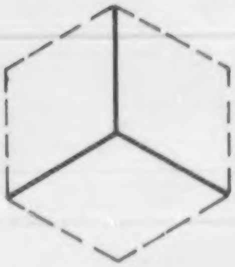
Positions of Isometric Axis Lines



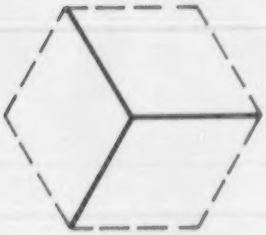
Top



Right Side

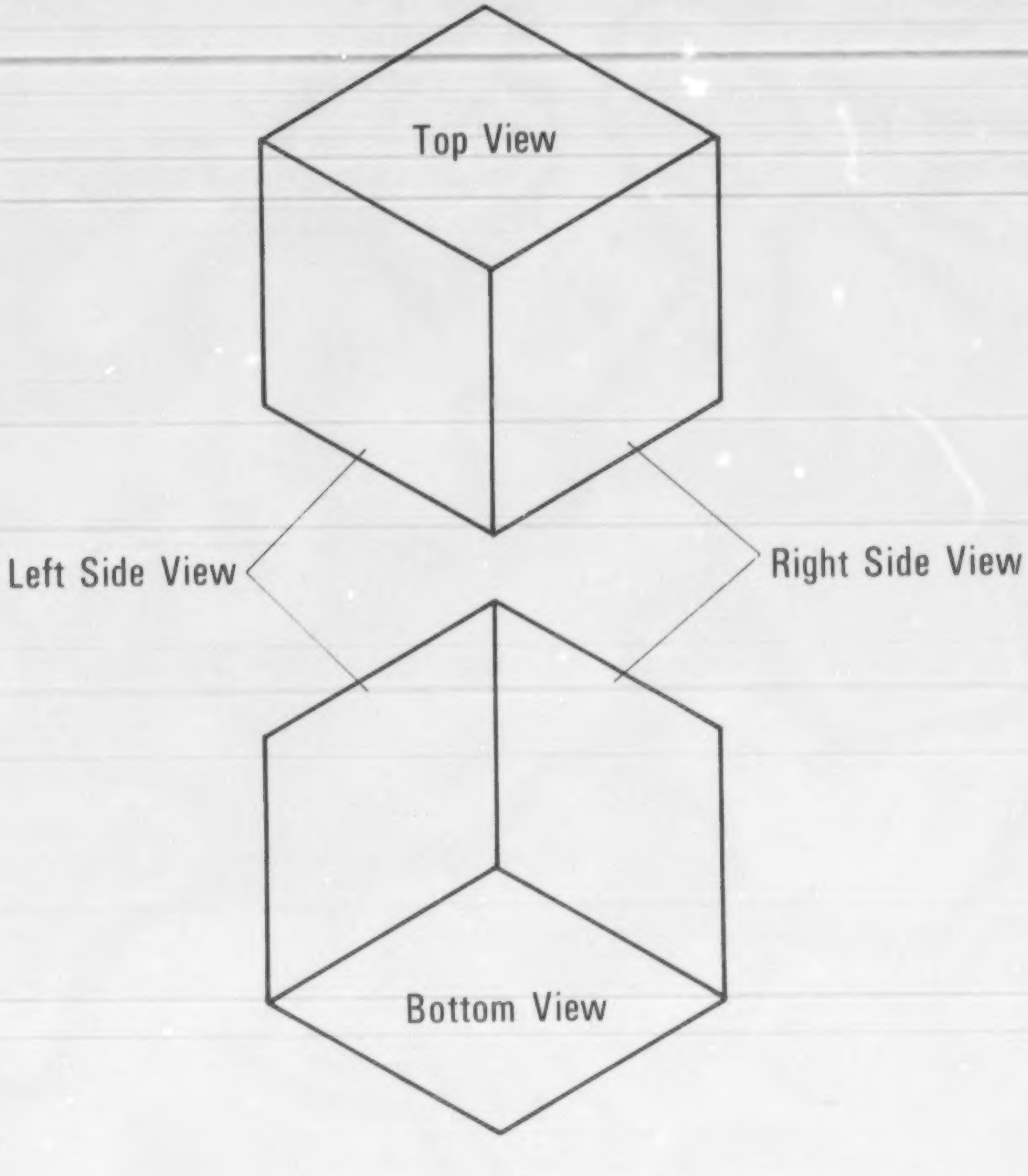


Bottom

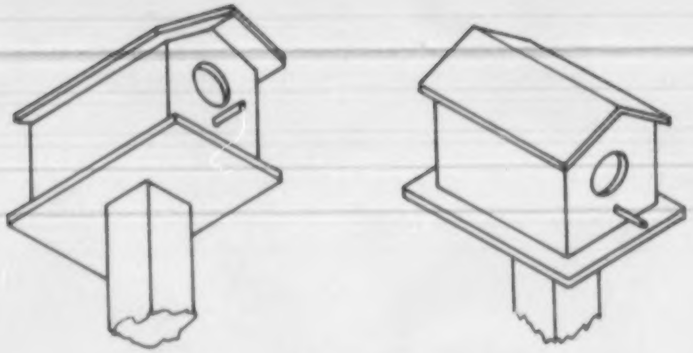


Left Side

Surfaces on an Isometric

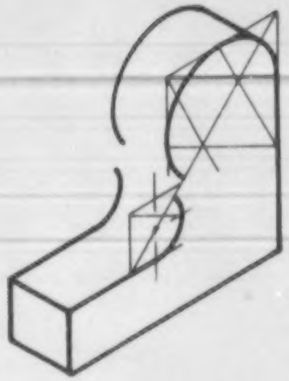

Top View
Left Side View
Right Side View
Bottom View

Errors on Isometrics



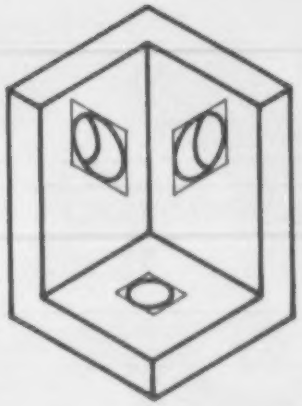
CORRECT INCORRECT

Object viewed from wrong direction

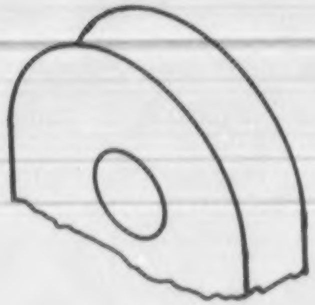


Circle arcs not tangent to each other

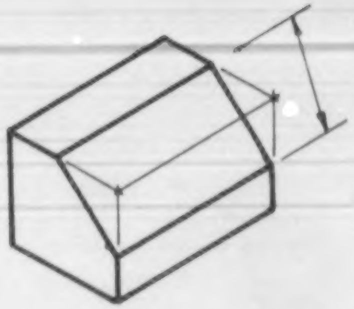
Ellipse not in proper plane



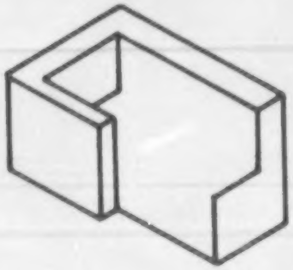
Errors on Isometrics
Continued



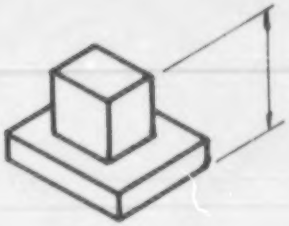
Tangent lines and rear ellipse missing



Angles not measured correctly



Isometric lines missing

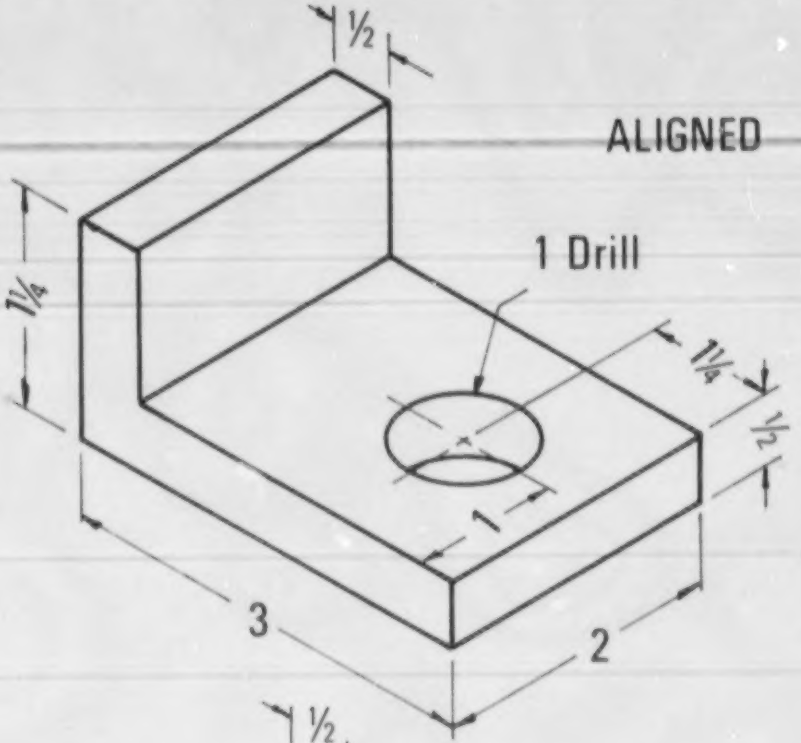


Dimensions not measured
parallel to isometric axis

TM 5

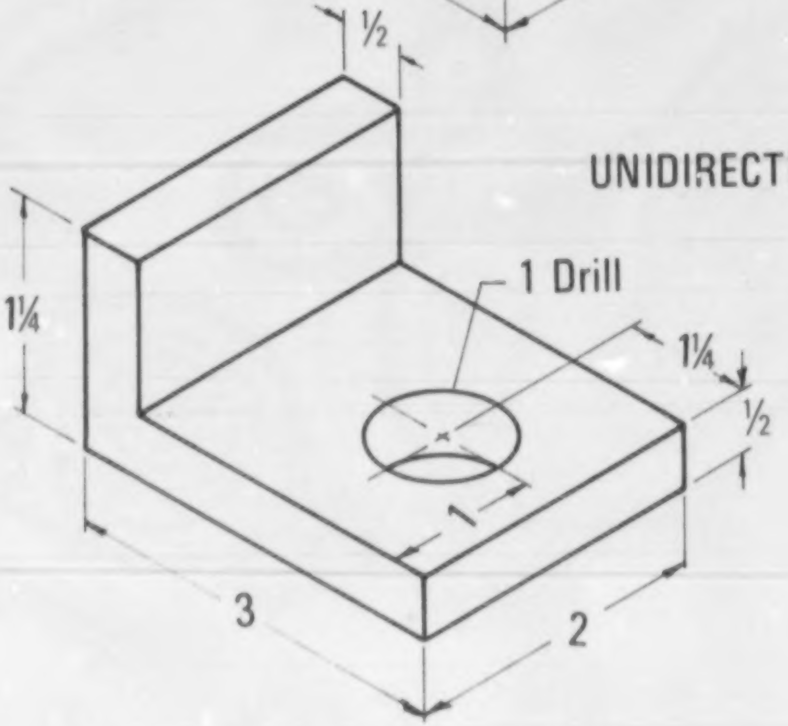
D II-761

Methods of Dimensioning Isometrics



ALIGNED

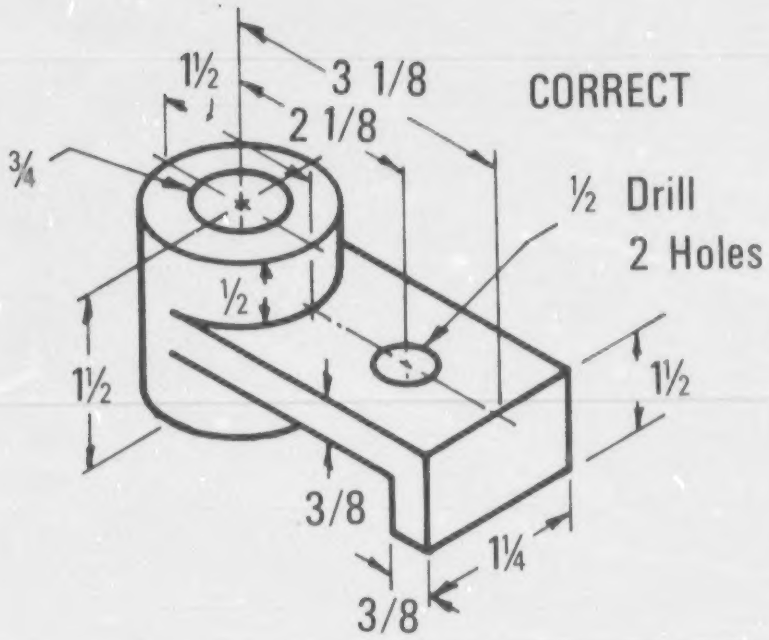
½
1 Drill
1¼
1¼
½
1
3
2

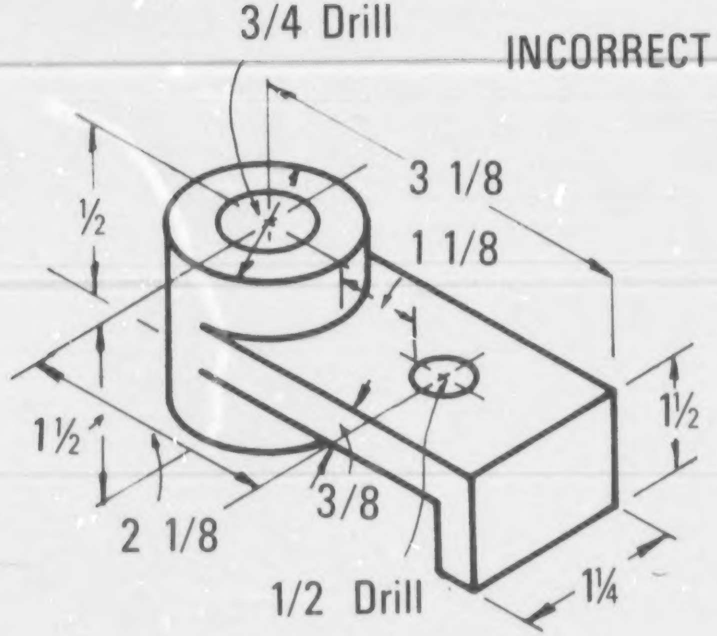


UNIDIRECTIONAL

½
1 Drill
1¼
1¼
½
1
3
2

Dimensioning Procedures


1½
3 1/8
CORRECT
2 1/8
¾
½ Drill
2 Holes
½
1½
1½
3/8
1¼
3/8


3/4 Drill
INCORRECT
3 1/8
½
1 1/8
1½
1½
2 1/8
3/8
1/2 Drill
1¼

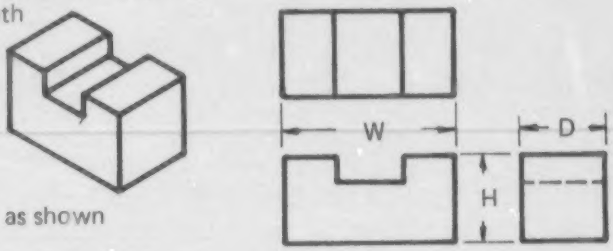
AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #1--SKETCH AN ISOMETRIC DRAWING

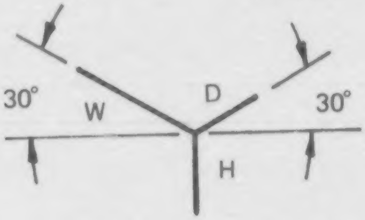
Premise: This type of sketching can be drawn from an actual object or from any multiview type drawing. An isometric sketch is drawn with both sides slanting back at a 30° angle. In sketching, this 30° angle is approximate. An isometric drawing can be sketched by using the procedure in the following example.

Example:

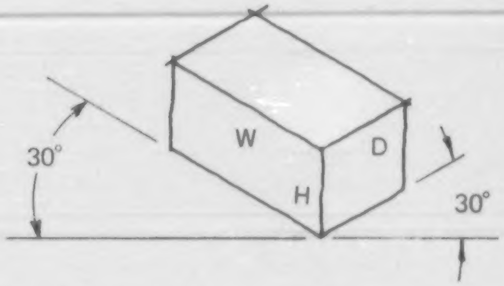
1. Use given actual object of multiview drawing and determine height, width, and depth



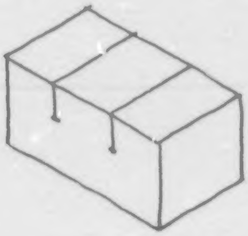
2. Lay off height, width, and depth as shown



3. Box in the outline of the object

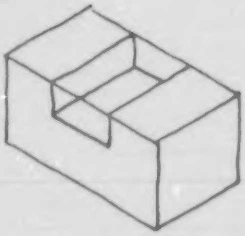


4. Locate object features such as slots, holes, and grooves

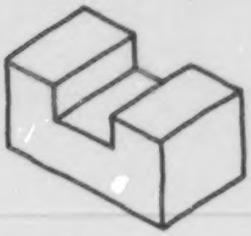


ASSIGNMENT SHEET #1

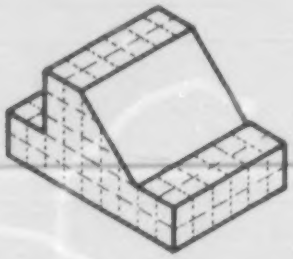
5. Complete shape of object



6. Erase construction lines and darken outline



Directions: Sketch an enlarged isometric of the object below.



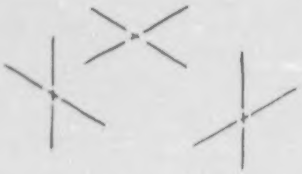
AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #2--SKETCH ISOMETRIC CIRCLES

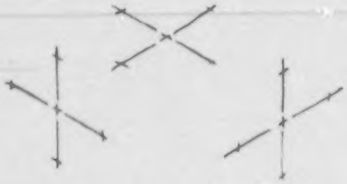
Premise: An isometric circle can be in the top, right side, or left side. In any case the circle should always be boxed in and then its individual arcs sketched to make the complete isometric circle. Isometric circles can be sketched by using the procedure in the following example.

Example:

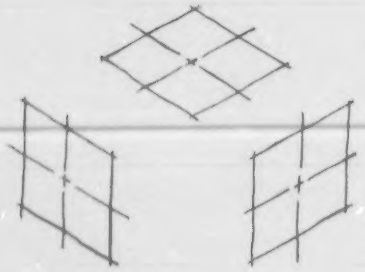
1. Lay out center lines



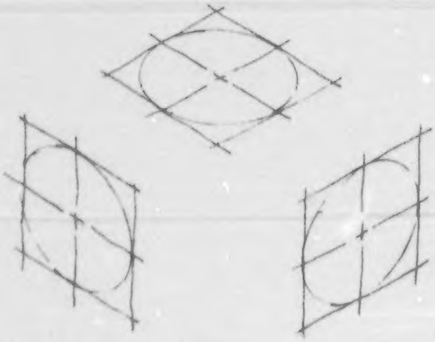
2. Mark off radius points



3. Box in circle outlines

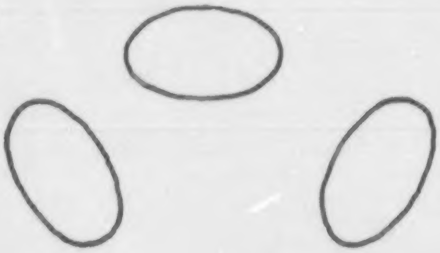


4. Sketch in arcs lightly



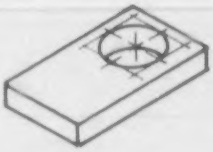
ASSIGNMENT SHEET #2

5. Erase construction lines and darken circles

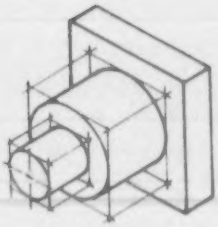


Directions: Make enlarged isometric sketches of the objects below in the space at the right.

Problem A:



Problem B:



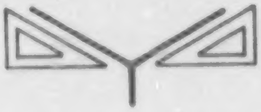
AXONOMETRICS
UNIT IX

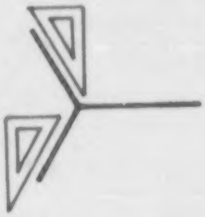
ASSIGNMENT SHEET #3--CONSTRUCT AN AXONOMETRIC DRAWING BY BOX METHOD

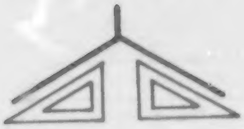
Premise: Axonometric drawings can be constructed by using the procedure in the following example. The same procedure is used for isometrics, dimetrics, and trimetrics except that the axis lines will differ.

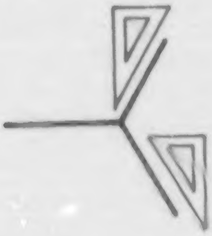
Example:

1. Attach sheet to drawing surface in alignment with working edge
2. Select position of isometric axis lines



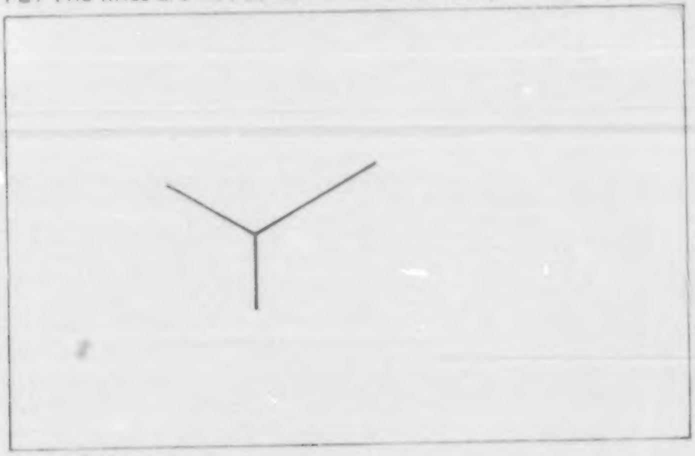






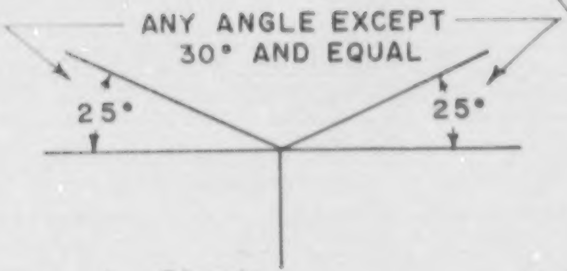
3. Locate axis lines on drawing media for the type of axonometric to be drawn

(NOTE: The lines are not centered on this example media.)

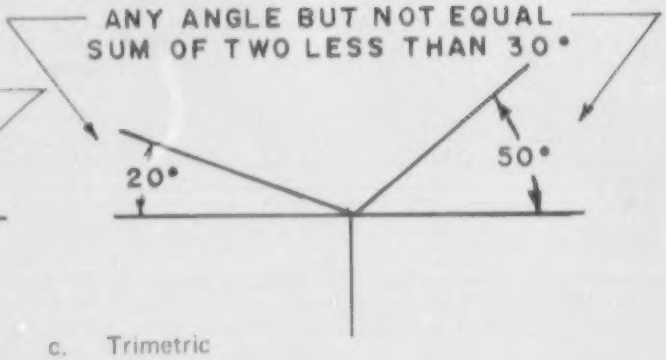


a. Isometric

ASSIGNMENT SHEET #3

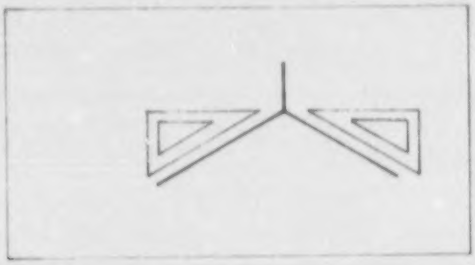

ANY ANGLE EXCEPT
30° AND EQUAL
25°
25°

b. Dimetric

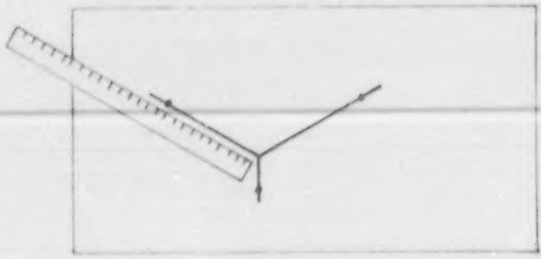

ANY ANGLE BUT NOT EQUAL
SUM OF TWO LESS THAN 30°
20°
50°

c. Trimetric

4. Extend lines from these axis lines with 30° 60° triangle or drafting machine

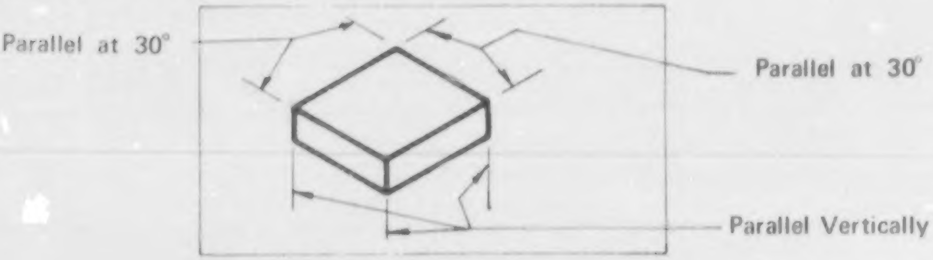


5. Measure overall width, depth, and height on these projected axis lines and mark point



6. Complete box with 30° 60° triangle or drafting machine making sure lines are parallel to main axis lines

(NOTE: The following drawing is isometric. Dimetric and trimetric axis lines will be parallel at different angles.)

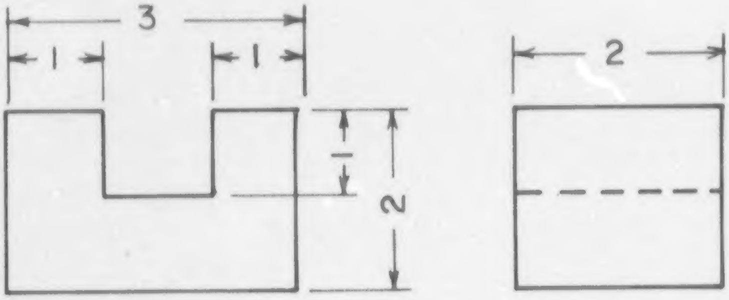

Parallel at 30°
Parallel at 30°
Parallel Vertically

ASSIGNMENT SHEET #3

7. Add details to object by removing parts of box not needed.

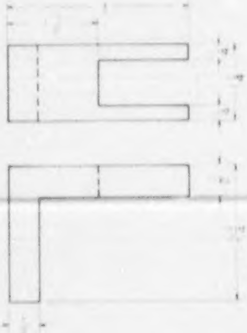
Directions: Construct an isometric drawing of the following object. Use top axis position.

Problem A:



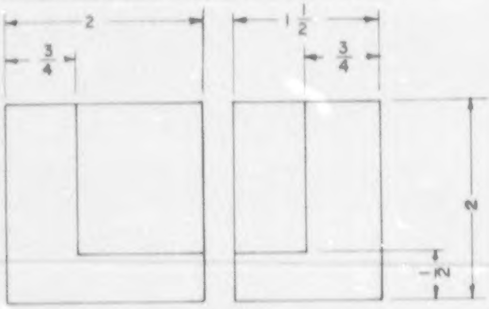
Directions: Construct a dimetric drawing of the following object. Use top axis position and 20° angles.

Problem B:



Directions: Construct a trimetric drawing of the following object. Use top axis position and 20° and 50° angles.

Problem C:

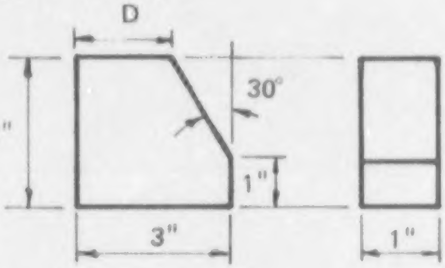


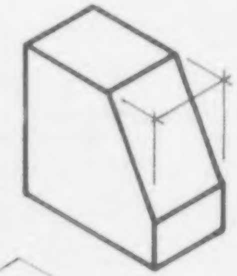
AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #4–CONSTRUCT ANGLES ON AN ISOMETRIC

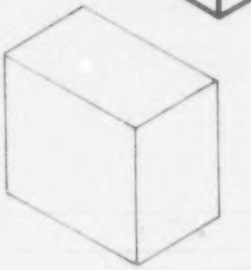
Premise: Angles on an isometric can be constructed by using the procedure in the following example. The example will use the dimensions of the following object on the left to construct the object on the right.

Example:

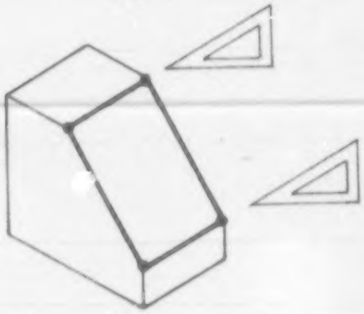




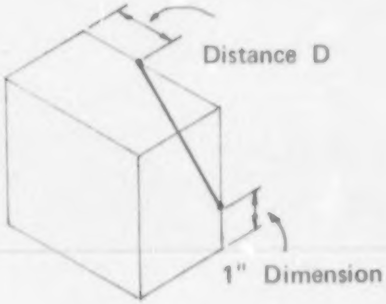
1. Box in overall dimensions of the object in isometric



2. Use dividers to lay out offset dimensions of angle and connect points

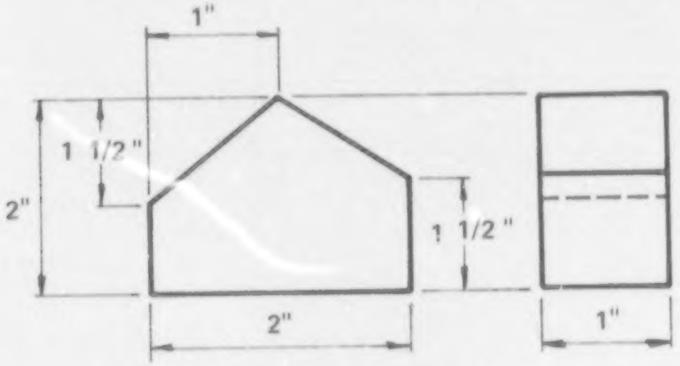


3. Complete the other side after extending lines across with 30° 60° triangle or drafting machine



ASSIGNMENT SHEET #4

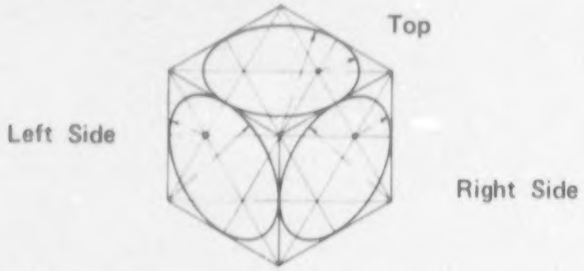
Directions: Construct the following object in isometric using the correct method to construct angles. Use top axis position and construct long dimension to left.



AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #5--CONSTRUCT ISOMETRIC CIRCLES AND ARCS

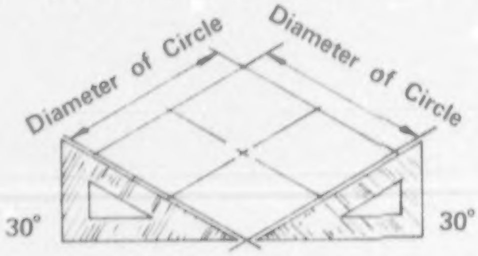
Premise: A circle can appear as an ellipse in the top, left side, or right side. The procedure for constructing the ellipses is the same but each is in a separate plane. Isometric circles and arcs can be constructed by using the procedures in the following examples. Examples are given for constructing circles in top and side planes using a 30° 60° triangle or drafting machine and ellipse templates. Examples are also given for constructing arcs using a 30° 60° triangle or drafting machine and ellipse template.



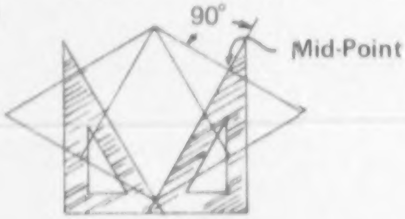
Example A: Circle in top plane

1. Locate center of circle and lay out center lines with a 30° 60° triangle or drafting machine

2. Locate diameter of circle by measuring its radius from the center point along the center lines

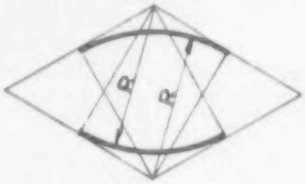


3. Erect perpendicular bisectors to each side, using the 30° 60° triangle or drafting machine as shown; these perpendiculars will intersect at four points, which will be centers for the four circular arcs

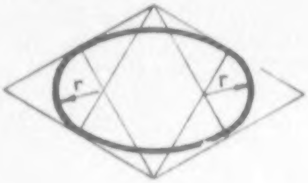


ASSIGNMENT SHEET #5

4. Draw the two large arcs, with radius R, from the intersections of the perpendiculars in the two closest corners of the parallelogram as shown

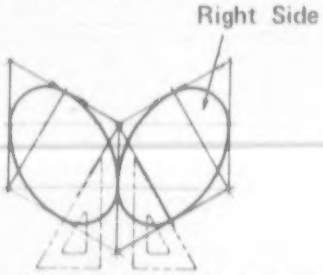


5. Draw the two small arcs, with radius r, from the intersections of the perpendiculars within the parallelogram, to complete the ellipse

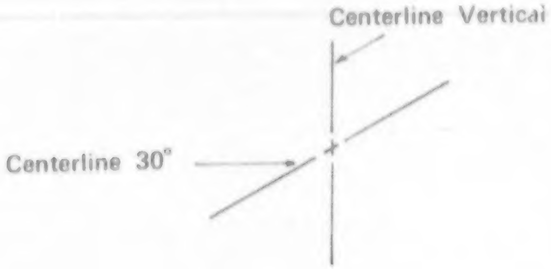


Example B: Circle in side plane

(NOTE: The method for constructing isometric circles is the same for both sides of the box. In this example the right side plane will be used.)

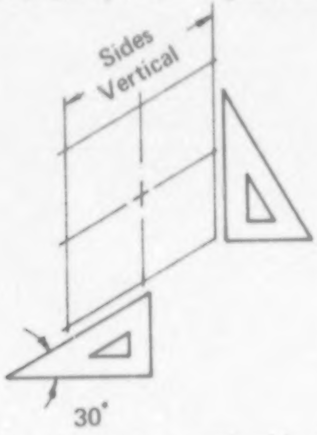


1. Locate center of circle and lay out centerlines with 30° 60° triangle or drafting machine

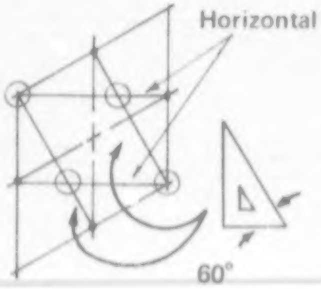


ASSIGNMENT SHEET #5

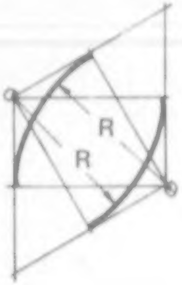
2. Locate diameter of circle by measuring its radius from the centerpoint along the center lines



3. Erect perpendicular bisectors to each side as shown; use the intersecting points as centers for the arcs

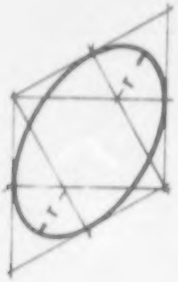


4. Draw the two large arcs with radius R, from the intersection of the perpendiculars from the two closest corners



ASSIGNMENT SHEET #5

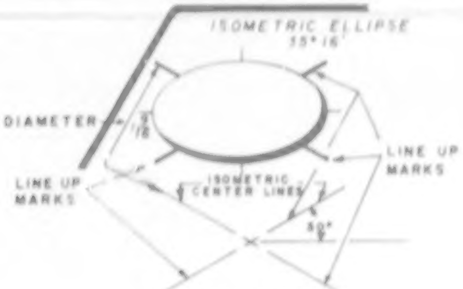
5. Draw the two small arcs, with radius r, from the intersection of the perpendicular lines within the parallelogram to complete the figure



Example C: Circles with ellipse template

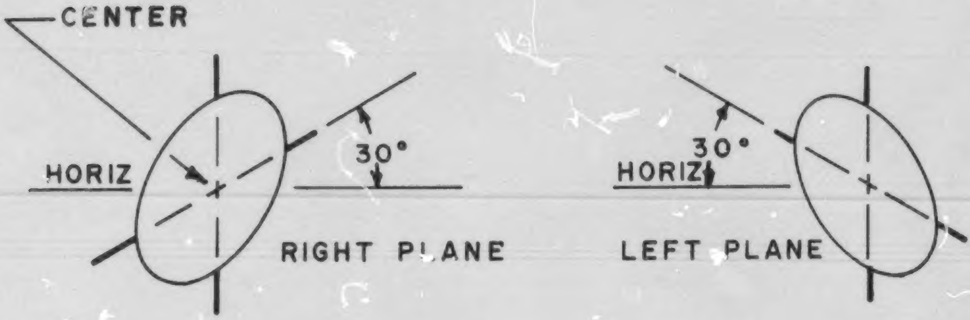
(NOTE: For convenience and time saving, isometric ellipse templates (35° 16' should be used. These ellipses have centerline marks that are parallel to two of three major axis lines on the isometric drawing.)

1. Construct isometric centerlines that are parallel to two axis lines
2. Select template marked isometric ellipses
3. Select correct diameter marked on template
4. Position template so that the four line-up marks are at a 30° angle from horizontal
5. Line up ellipse template marks on center lines; construct ellipse


ISOMETRIC ELLIPSE
35° 16'
DIAMETER
3/16
LINE UP MARKS
LINE UP MARKS
ISOMETRIC CENTER LINES
30°
HORIZ PLANE

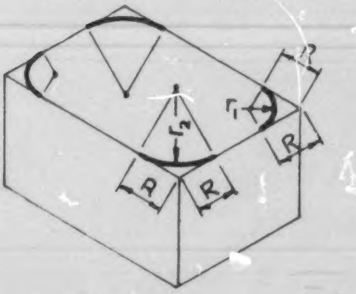
ASSIGNMENT SHEET #5

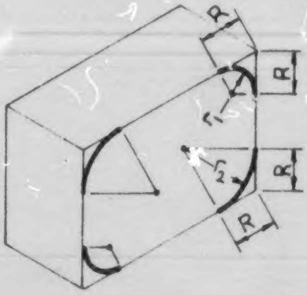
6. To position the ellipse on the center lines in the other planes, use the same marks; place two of them vertically and the other two marks are at a 30° angle from horizontal


CENTER
HORIZ
30°
RIGHT PLANE
30°
HORIZ
LEFT PLANE

Example D: Arcs

(NOTE: Arcs in isometric pose another problem in determining which plane to lay out the isometric box and which part of the elliptical circle to use. The required radius R is measured equally and in each case is measured from the corner where the arc is to be located as shown in the following illustration.

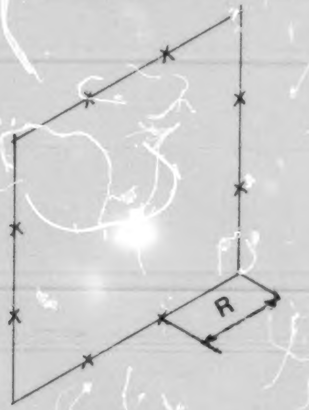




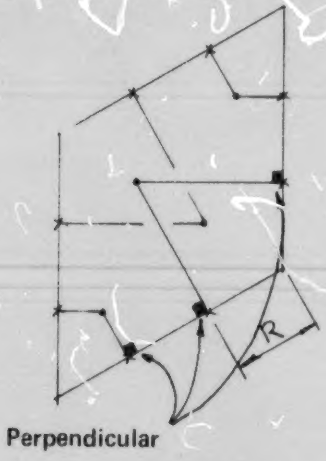
ASSIGNMENT SHEET #5

1. Mark off radius points from the corners along the box lines

   (NOTE: In this example 1/4" R arcs will be constructed.)

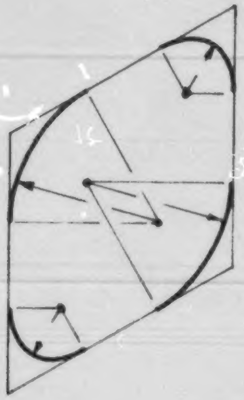


2. Erect construction lines inside the circle perpendicular to each of the lines on which the radius points are marked



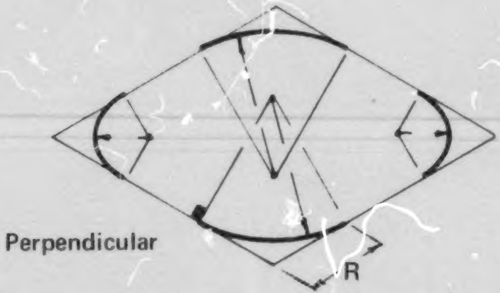
ASSIGNMENT SHEET #5

3. Set compass at radius of line intersections and put in arcs as shown on all four corners



(NOTE: Heavy dots inside box are line intersections and are used for radius points.)

4. If plane where arcs are needed should be in the top, the procedure is the same; after points are located, swing arcs from intersecting lines as shown



Example E: Arcs with ellipse template

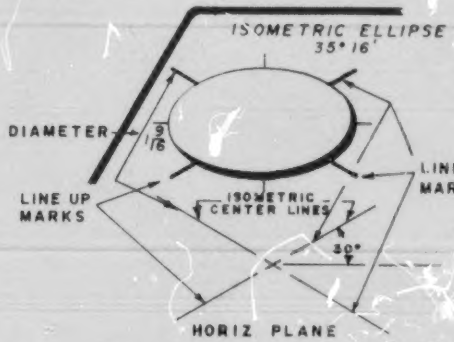
(NOTE: The principle for constructing arcs is the same as circles, but only 1/4 of an ellipse is used.)

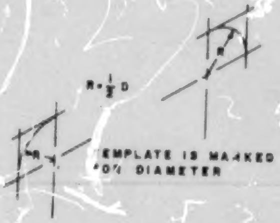
1. Mark off radius points from corners along the box lines
2. Construct isometric center lines parallel to box lines
3. Select correct ellipse size for radius

ASSIGNMENT SHEET #5

4. Position template line-up marks on center lines; construct required arc

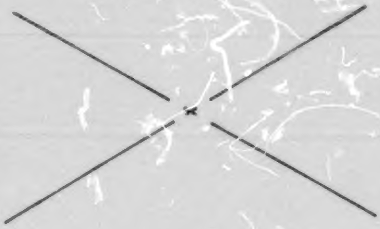
(NOTE: Arc lengths greater than or less than one-fourth circle are determined by marking tangent points.)


ISOMETRIC ELLIPSE
35° 16'
DIAMETER
1 9/16
LINE UP MARKS
ISOMETRIC CENTER LINES
LINE UP MARKS
30°
HORIZ PLANE


R = 1/2 D
R
R
TEMPLATE IS MARKED FOR DIAMETER

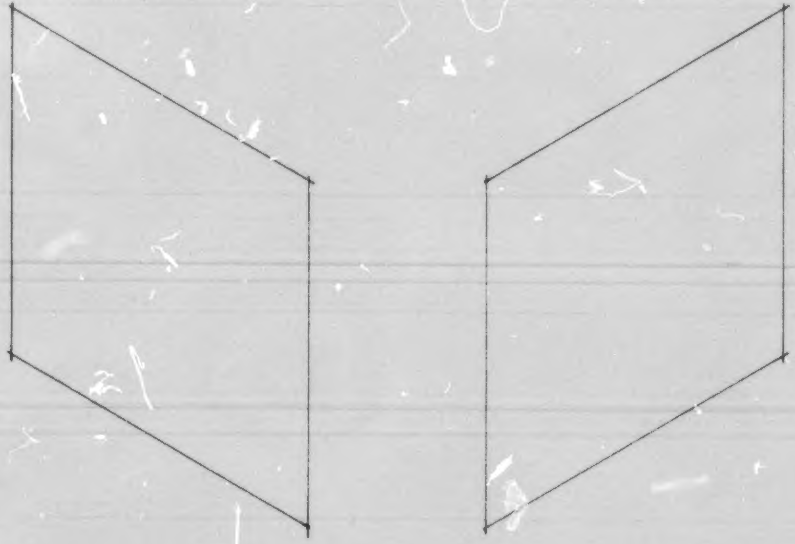
Directions: Construct an isometric circle with a diameter of 2" using the procedure outlined in Example A.

Problem A:



Directions: Construct isometric circles in right and left plane in the boxes below using the procedure outlined in Example B.

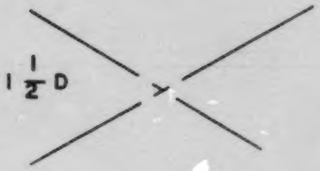
Problem B:

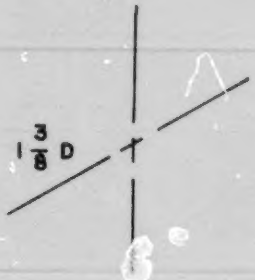


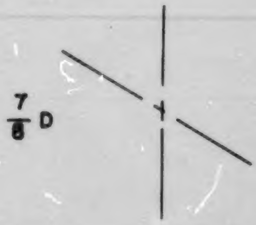
ASSIGNMENT SHEET #5

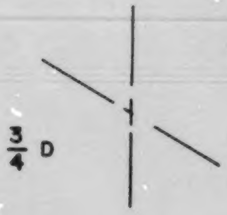
Directions: Construct isometric circles on the following center lines using isometric ellipse template and procedure outlined in Example C.

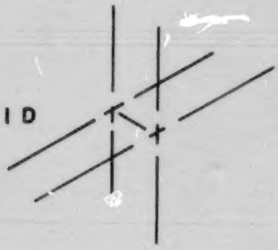
Problem C:

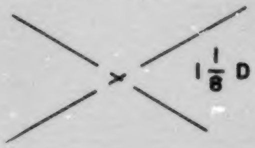






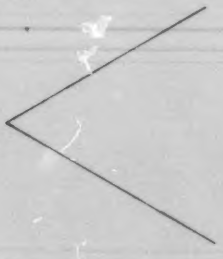


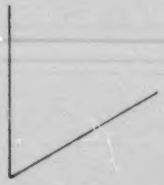


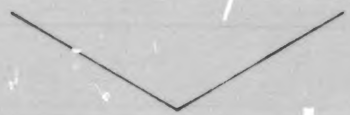


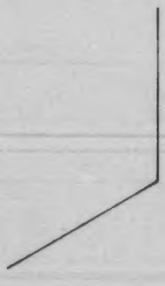
Directions: Construct 1/2" radius arcs in the corners of the following boxes using procedure outlined in Example D.

Problem D:





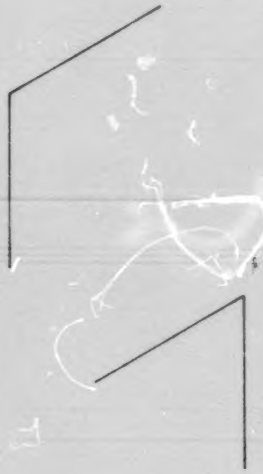


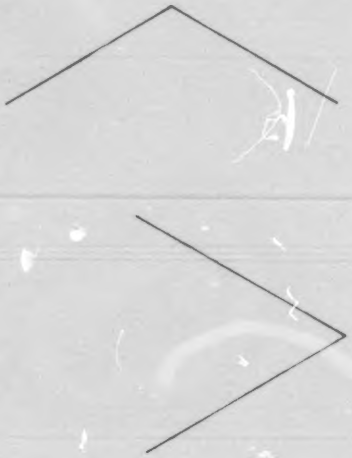


ASSIGNMENT SHEET #5

Directions: Construct 1/2" radius arcs in the corners of the following boxes using circle template and procedure outlined in Example E.

Problem E:

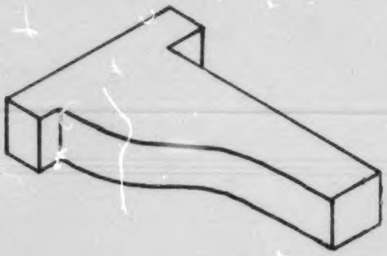




AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #6--CONSTRUCT ISOMETRIC CURVES BY COORDINATES

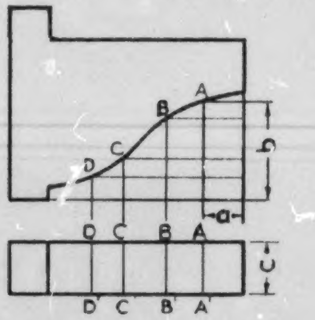
Premise: Circles and arcs that are not regular make it necessary to use points to lay out the curve. Isometric curves such as in the following illustration can be constructed by coordinates using the procedure in the following example.



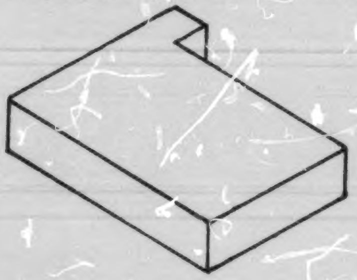
Example:

1. Locate coordinate points along the curve as at A, B, C, and D

2. Mark distance a and b as shown on top view of orthographic

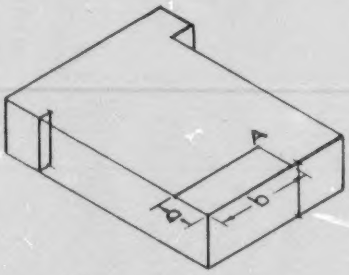


3. Draw isometric box in position desired to illustrate object

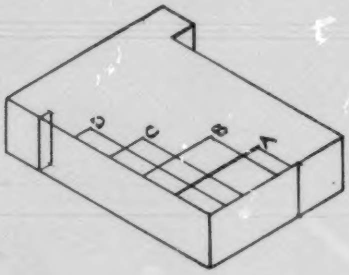


ASSIGNMENT SHEET #6

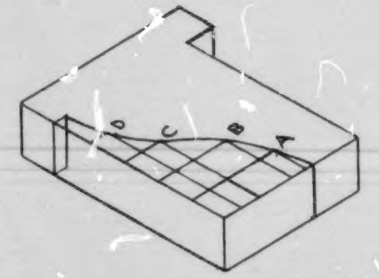
4. Along right and left edges lay out coordinate distances a and b from orthographic view in step #2; this locates point A



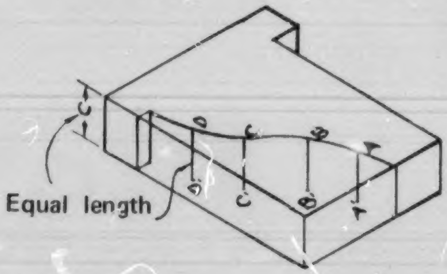
5. Locate points B, C, and D in the same manner as point A was located



6. Use irregular curve to connect points

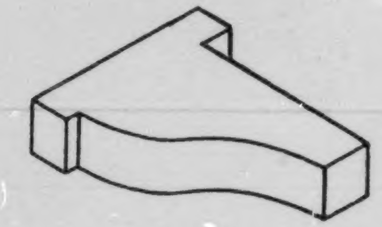


7. Locate curve points at bottom edge by dropping them down the thickness of the object


C
D
C
B
A
D
C
B
A
Equal length

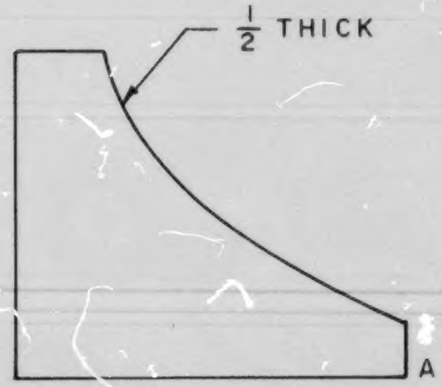
ASSIGNMENT SHEET #6

8. Use irregular curve to put in bottom edge; darken visible lines



Directions: Construct an isometric drawing of the following object beginning with point A.

Problem:



AXONOMETRICS
UNIT IX

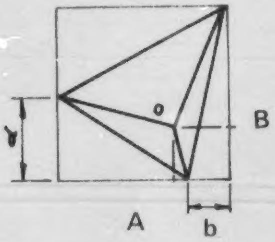
ASSIGNMENT SHEET #7--MEASURE IN ISOMETRIC BY OFFSETS

Premise: Isometrics can be measured by offsets using the procedure in the following example.

Example:

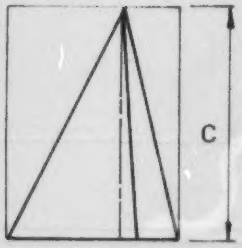
1. Box in outline of top and front view

Top View

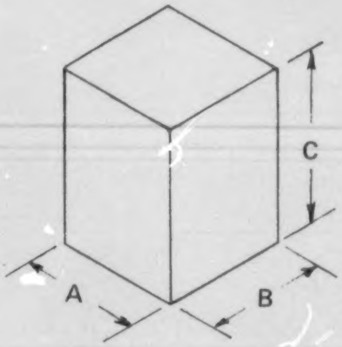


2. Locate points on outline of box as at a and b

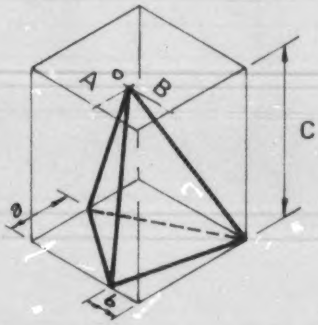
Front View



3. Lay out isometric box with same height, width, and depth of object

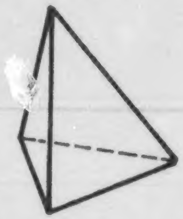


4. Locate points on isometric box by locating them on their correct plane; all measurements must be made parallel to isometric lines, such as the outline of the box



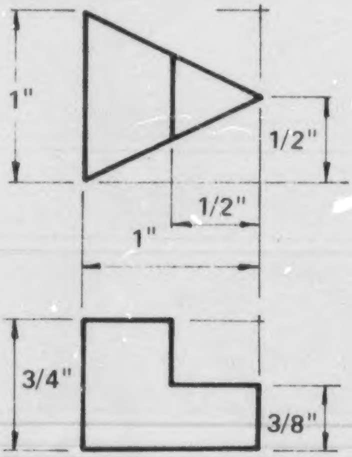
ASSIGNMENT SHEET #7

5. Erase construction lines and darken outline of the object



Directions: Construct the two views as an isometric.

Problem:



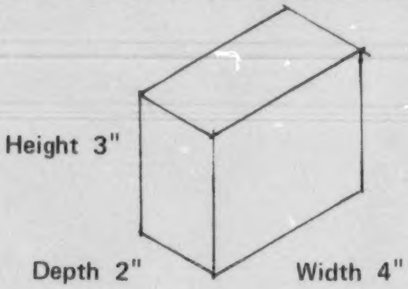
AXONOMETRICS
UNIT IX

ASSIGNMENT SHEET #8--CONSTRUCT AN ISOMETRIC IN THE CENTER OF A DRAWING MEDIA

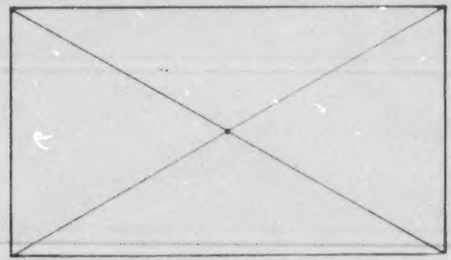
Premise: It is important that isometric drawings be located somewhere near the center of the drawing media that is available to allow room for dimensions, notes, and to add to the neatness of the object. Isometrics can be constructed in the center of a drawing media by using the procedure in the following example.

Example:

1. Make an isometric box sketch of the overall dimensions of the object to be drawn



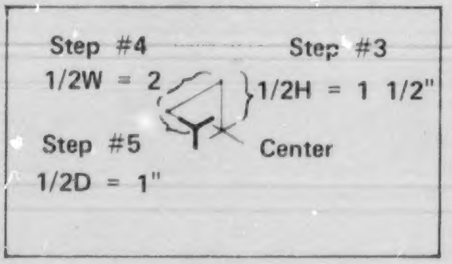
2. Find center of drawing media by using diagonals from corners



3. From the center of the work area, measure vertically 1/2 the height of the object (1 1/2" in this example)

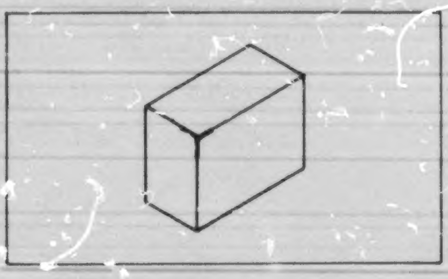
4. At a 30° angle down and to the left, measure 1/2 the width of the object (2" in this example)

5. At a 30° angle to the right and down, measure 1/2 the depth of the object (1" in this example); this point is the front corner of the object to be drawn



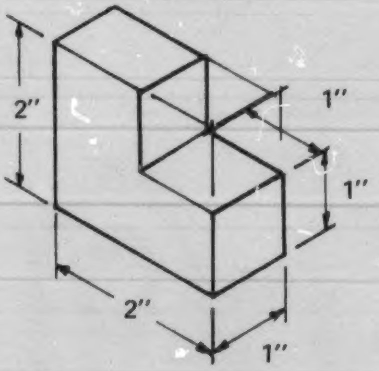
ASSIGNMENT SHEET #8

6. From this point, complete the object as an ordinary isometric by boxing in the outline, adding features, and erasing construction lines



Directions: Center the isometric object in the space below with longest dimension to left.

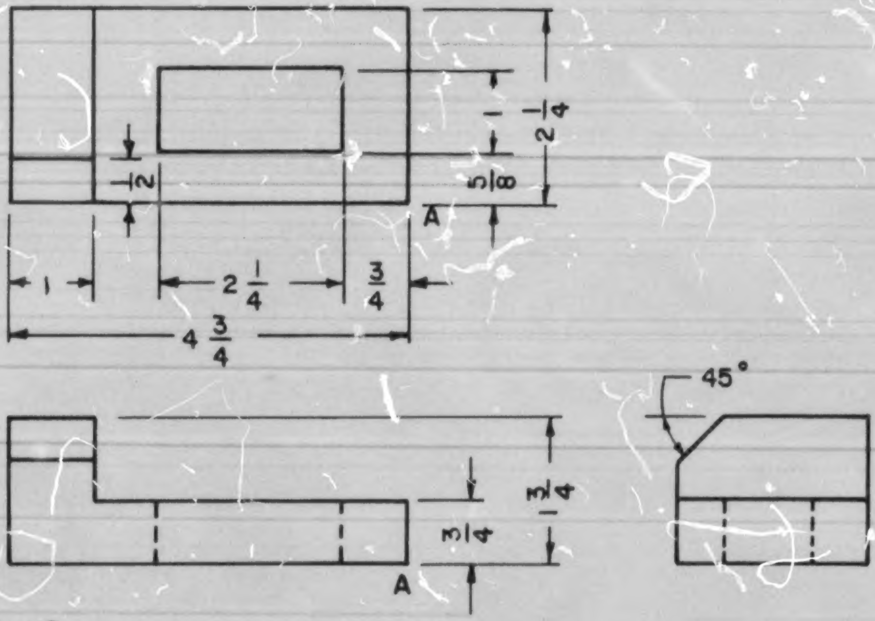
Problem A:



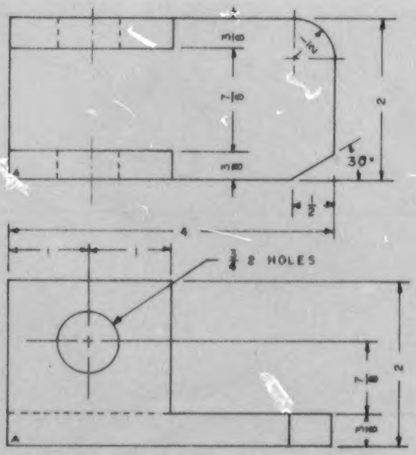
ASSIGNMENT SHEET #8

Directions: Center and construct isometrics for the following problems on "A" size vellum. Use standard borders and title block. Omit dimensions and erase construction lines. Start with point A.

Problem B:


1/2
1
2 1/4
3/4
4 3/4
1
2 1/4
5/8
A
45°
3/4
1 3/4
A

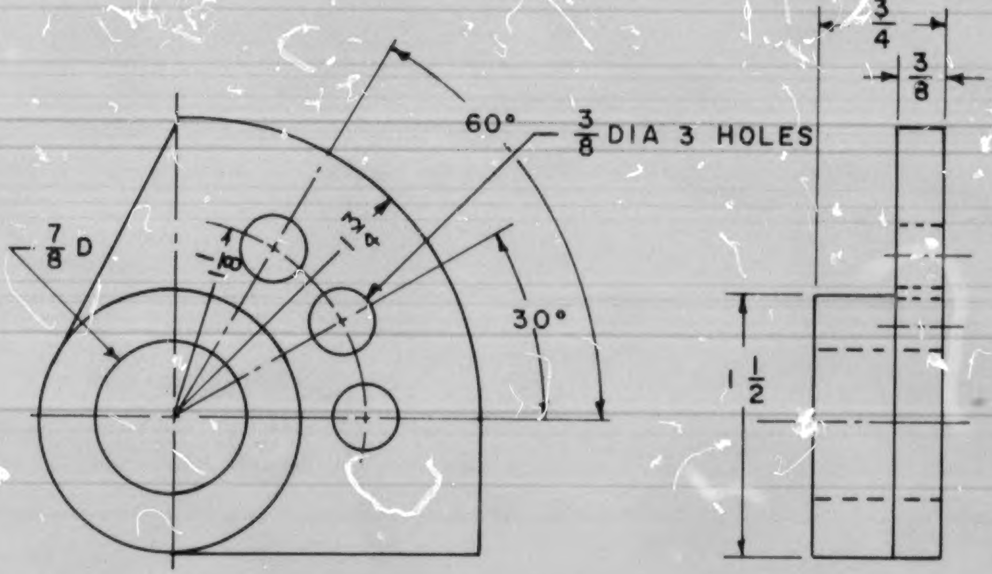
Problem C:


3/8
7/8
3/8
1/2
2
30°
1/2
4
1
1
3/4 2 HOLES
7/8
3/8
2
A
A

ASSIGNMENT SHEET #8

Directions: Center and construct an isometric of the following object on "A" size vellum. Use standard borders and title block. Dimension the drawing.

Problem D:

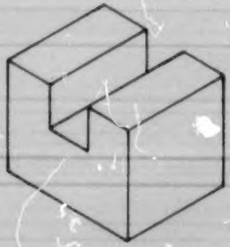

60°
3/8 DIA 3 HOLES
7/8 D
1 1/8
1 3/4
30°
3/4
3/8
1 1/2

AXONOMETRICS
UNIT IX

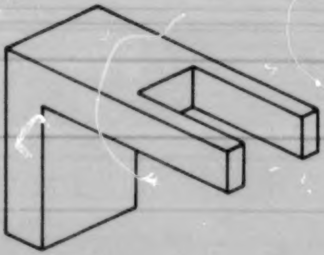
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #3

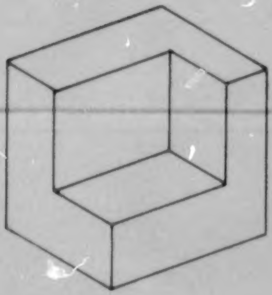
A.



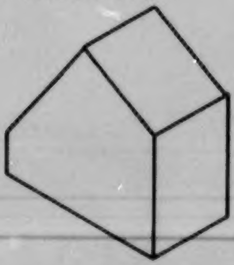
B.



C.

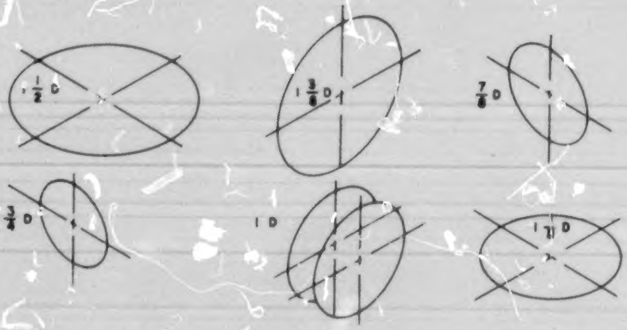


Assignment Sheet #4

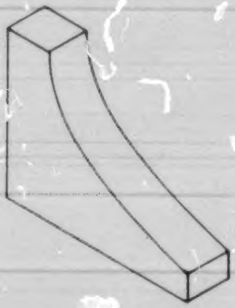


Assignment Sheet #5

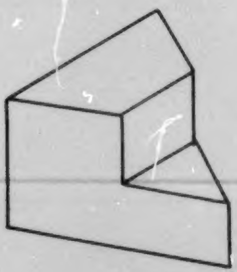
C.


1 1/2 D
1 3/8 D
7/8 D
3/4 D
1 D
1 1/4 D

Assignment Sheet #6

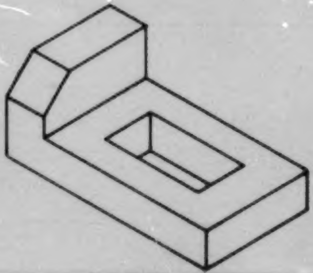


Assignment Sheet #7

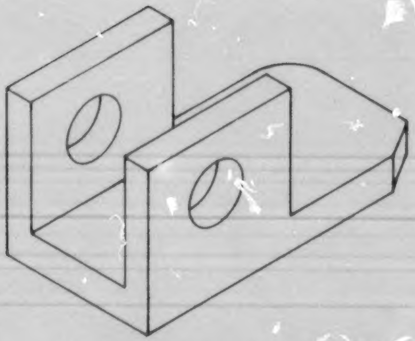


Assignment Sheet #8

B.



C.



AXONOMETRICS
UNIT IX

NAME ____________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Suggesting a picture or mental image

_____b. A type of axonometric drawing with each of the three planes and axes equal to each other

_____c. A type of axonometric drawing with two planes on equal axes to each other and a third plane of a different angle

_____d. A type of axonometric drawing with all three planes and axes not equal to each other

_____e. To appear shorter to the eye than it actually is

_____f. The lines used to represent surfaces or planes coming together

_____g. To extend from one point to another

_____h. The lines that run parallel to the isometric axis lines

_____i. The lines that do not run parallel to the isometric axis lines

_____j. A foreshortened circle with a major and minor diameter

_____k. A type of pictorial with each of the three planes and axes at any angle and not equal to 90°

_____l. A method of locating a point from a horizontal and a vertical line

1. Offset coordinates
2. Axis lines
3. Axonometric
4. Pictorial
5. Ellipse
6. Projection
7. Foreshortened
8. Dimetric
9. Isometric
10. Trimetric
11. Isometric lines
12. Non-isometric lines

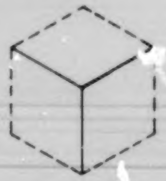
2. List three types of axonometric drawings.

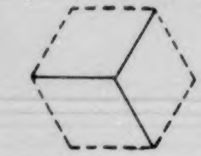
a. ____________________

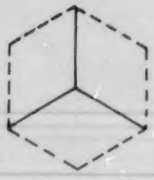
b. ____________________

c. ____________________

3. Identify the positions used as axis lines for isometric drawings.







a. ____________ b. ____________ c. ____________

4. Identify plane surfaces on isometrics below.

a. ____________________

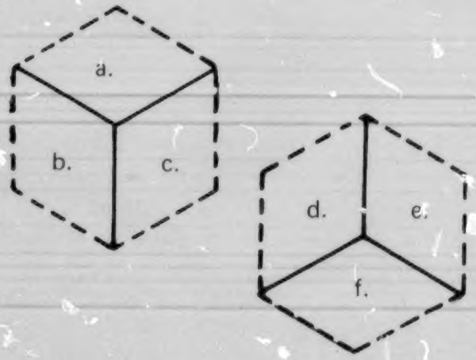
b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________



5. Select true statements concerning rules in constructing an isometric drawing by placing an "X" in the appropriate blanks.

______a. All measurements are made parallel to the main edges of the isometric axis lines

______b. Angles are measured with a protractor in isometrics

______c. Hidden lines are always shown on isometric drawings

______d. Isometric drawings are detailed and then centered in their space

______e. Always block in a circle before constructing its arcs

______f. The sight direction that best represents the object should be used for the isometric position

______g. If lines are parallel in two successive orthographic views, they will never be parallel in isometric views

6. Match common errors made in isometric drawing below with their correct drawings.

_____a. Lines of isometric omitted

_____b. Ellipses not in proper plane

_____c. Angles not measured correctly

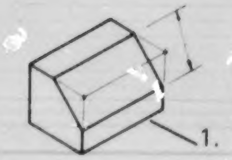
_____d. Tangent lines missing from circles and arcs

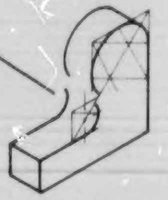
_____e. Circle arcs not tangent to each other

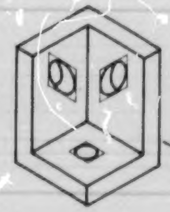
_____f. Dimensions not measured parallel to isometric axis lines

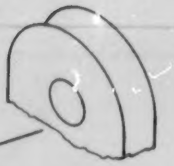
_____g. Rear ellipse of a hole missing

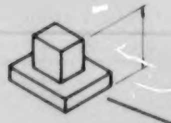
_____h. Object viewed from wrong direction

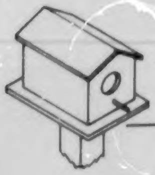

1.

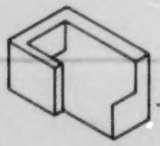

3.


6.


2.


4.


7.


5.

7. Distinguish between the advantages and disadvantages of isometric drawing by placing an "A" for advantage and a "D" for disadvantage in the appropriate blanks.

_____a. Easy to construct

_____b. Long objects appear distorted

_____c. Symmetrical type drawing causes some lines to meet or overlap, confusing the viewer

_____d. Three sides of an object may be shown in one view

_____e. Circles are not very distorted

8. Select methods of dimensioning an isometric by placing an "X" in the appropriate blanks.

______a. Template

______b. Aligned

______c. Unidirectional

9. Select true statements concerning rules in dimensioning an isometric drawing by placing an "X" in the appropriate blanks.

______a. Notes should be parallel to dimension lines

______b. Use guidelines for all notes

______c. Dimension size of holes with notes and leaders

______d. Dimension and extension lines should be parallel to the horizontal line

______e. All dimensions must be put in by the aligned method

______f. Dimensions should be to hidden surfaces

______g. Keep dimensions off object if possible

______h. Keep dimension lines evenly spaced and not crowding the drawing

10. Demonstrate the ability to:

a. Sketch an isometric drawing.

b. Sketch isometric circles.

c. Construct an axonometric drawing by box method.

d. Construct angles on an isometric.

e. Construct isometric circles and arcs.

f. Construct isometric curves by coordinates.

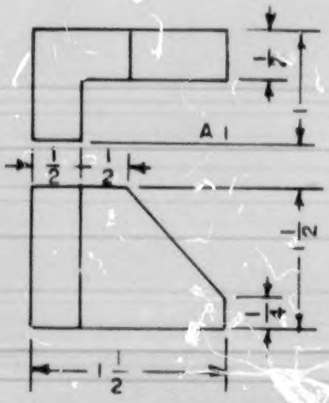
g. Measure in isometric by offsets.

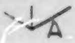
h. Construct an isometric in the center of a drawing media.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

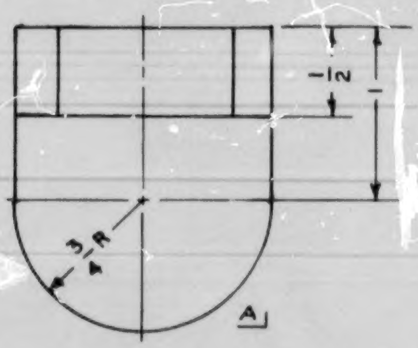
11. Construct isometric drawings of the following objects. Begin each drawing at point A. Omit the dimensions.

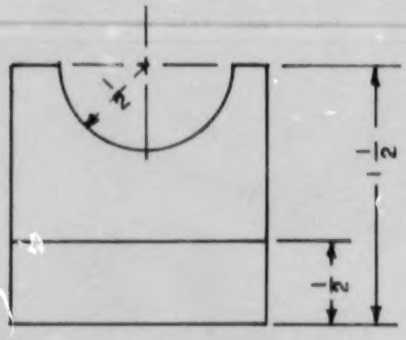
a.


1/2
1
A
1/2
1/2
1 1/2
1/4
1 1/2



b.





AXONOMETRICS
UNIT IX

ANSWERS TO TEST

1. a. 4 g. 6
b. 9 h. 11
c. 8 i. 12
d. 10 j. 5
e. 7 k. 3
f. 2 l. 1

2. a. Isometric
b. Dimetric
c. Trimetric

3. a. Top c. Bottom
b. Right side

4. a. Top d. Left side
b. Left side e. Right side
c. Right side f. Bottom

5. a, e, f

6. a. 5 d. 2 g. 2
b. 6 e. 3 h. 7
c. 1 f. 4

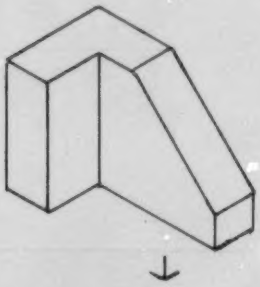
7. a. A d. A
b. D e. A
c. D

8. b, c

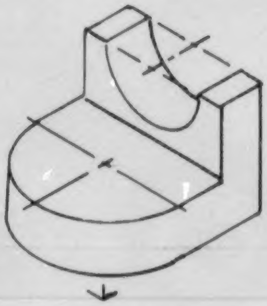
9. b, c, g, h

10. Evaluated to the satisfaction of the instructor

11. a.



b.



OBLIQUE
UNIT X

UNIT OBJECTIVE

After completion of this unit, the student should be able to select axis line position and box in an object in the center of a working space. The student should also be able to measure in oblique, construct angles, construct circles, and construct oblique drawings of various objects. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to oblique with their correct definitions.
2. List three types of oblique drawings.
3. Identify the positions used as axis lines on oblique drawings.
4. Name the two most common positions used as axis lines.
5. Select true statements concerning rules in constructing an oblique drawing.
6. Match common errors made in oblique drawing with their correct drawings.
7. List two methods of dimensioning an oblique.
8. Select true statements concerning rules in dimensioning an oblique drawing.
9. Demonstrate the ability to:
    a. Sketch an oblique.
    b. Construct an oblique drawing by box method.
    c. Measure in oblique.
    d. Construct angles on an oblique object.
    e. Construct oblique circles.
    f. Construct oblique circles in depth plane.
    g. Construct an oblique drawing in the center of a drawing space.
10. Construct a cavalier oblique drawing of a given object.
11. Construct a cabinet oblique drawing of a given object.

OBLIQUE
UNIT X

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Discuss the uses of oblique drawings and how the student decides when to make an oblique drawing.

VII. Show filmstrips or films which cover the fundamentals of oblique drawings. Refer to additional materials for suggested teaching aids.

VIII. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Oblique Drawings
      2. TM 2--Positions of Oblique Axis
      3. TM 3--Common Errors on Oblique Drawings
      4. TM 4--Common Errors on Oblique Drawings (Continued)
      5. TM 5--Methods of Dimensioning Obliques

   D. Assignment sheets

      1. Assignment Sheet #1--Sketch an Oblique
      2. Assignment Sheet #2--Construct an Oblique Drawing by Box Method
      3. Assignment Sheet #3--Measure in Oblique
      4. Assignment Sheet #4--Construct Angles on an Oblique Object

5. Assignment Sheet #5--Construct Oblique Circles
6. Assignment Sheet #6--Construct Oblique Circles in Depth Plane
7. Assignment Sheet #7--Construct an Oblique Drawing in the Center of a Drawing Space

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry.* South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

B. Giesecke, Frederick E., et al. *Technical Drawing.* New York: Macmillan Publishing Co., Inc., 1980.

C. Spence, William P. *Drafting Technology and Practice.* Peoria, IL 61614: Chas. A. Bennett Co., Inc., 1973.

D. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design.* New York: Gregg Division/McGraw-Hill Book Co., 1979.

III. Additional materials:

A. Transparencies--"The ABC's of Drafting." DCA Educational Products: DCA Incorporated; Warrington, PA 18976.

B. Filmstrip/cassette--"Drafting/Mechanical Drawing." Prentice Hall Media; Serv Code VD354; 150 White Plaines Road; Tarrytown, NY 10591.

OBLIQUE
UNIT X

INFORMATION SHEET

I. Terms and definitions

  A. Pictorial--Suggesting a picture or mental image

  (NOTE: Three types of pictorials are axonometric, oblique, and perspective.)

  B. Oblique--A type of pictorial drawing with front plane true size and parallel to frontal plane, the other two at any angle to the front

  C. Cavalier--A type of oblique drawing with all axis lines drawn true length

  D. Cabinet--A type of oblique drawing with the depth axis drawn half scale and the other axis lines drawn true length

  E. General--A type of oblique drawing with the depth axis drawn at any scale

  F. Foreshortened--To appear shorter to the eye than it actually is

  G. Axis lines--The lines used to represent where planes come together

  H. Project--To extend from one point to another

  I. Oblique lines--The lines that run parallel with one of the oblique axis lines

  J. Non-oblique lines--The lines that do not run parallel to one of the oblique axis lines

  K. Ellipse--A foreshortened circle with a major and minor diameter

II. Types of oblique drawings (Transparency 1)

  A. Cavalier

  B. Cabinet

  C. General

III. Positions used as axis lines on oblique drawings (Transparency 2)

  A. Up to right

  B. Down to right

  C. Up to left

  D. Down to left

INFORMATION SHEET

IV. Most common positions used as axis lines

  A. Up to left

  B. Up to right

V. Rules in constructing an oblique drawing

  A. All measurements are made parallel to the main axis edges of the oblique axis lines

  B. Angles are measured by coordinate offsets

  C. Hidden lines are omitted in oblique drawings if possible

  D. A drawing should be centered in the work space and boxed in before adding details

  E. Use the approximate ellipse method on circles that cannot be drawn as regular circles or if no templates are available

  F. Always box in a circle before constructing its arcs

  G. Always face contours toward the frontal plane where they appear in true size and shape and can be drawn with compass

  H. Draw long objects with the long axis perpendicular to the line of sight

  I. Keep all arcs and lines tangent to each other

  J. Include the rear ellipse or circle of a hole if it is visible

VI. Common errors made in oblique drawing (Transparencies 3 and 4)

  A. Wrong axis selected

  B. Arcs not tangent

  C. Tangent lines omitted

  D. Rear circle or ellipse omitted

  E. Line missing

  F. Plane with the longest dimension not in front plane

VII. Methods of dimensioning an oblique (Transparency 5)

  A. Aligned

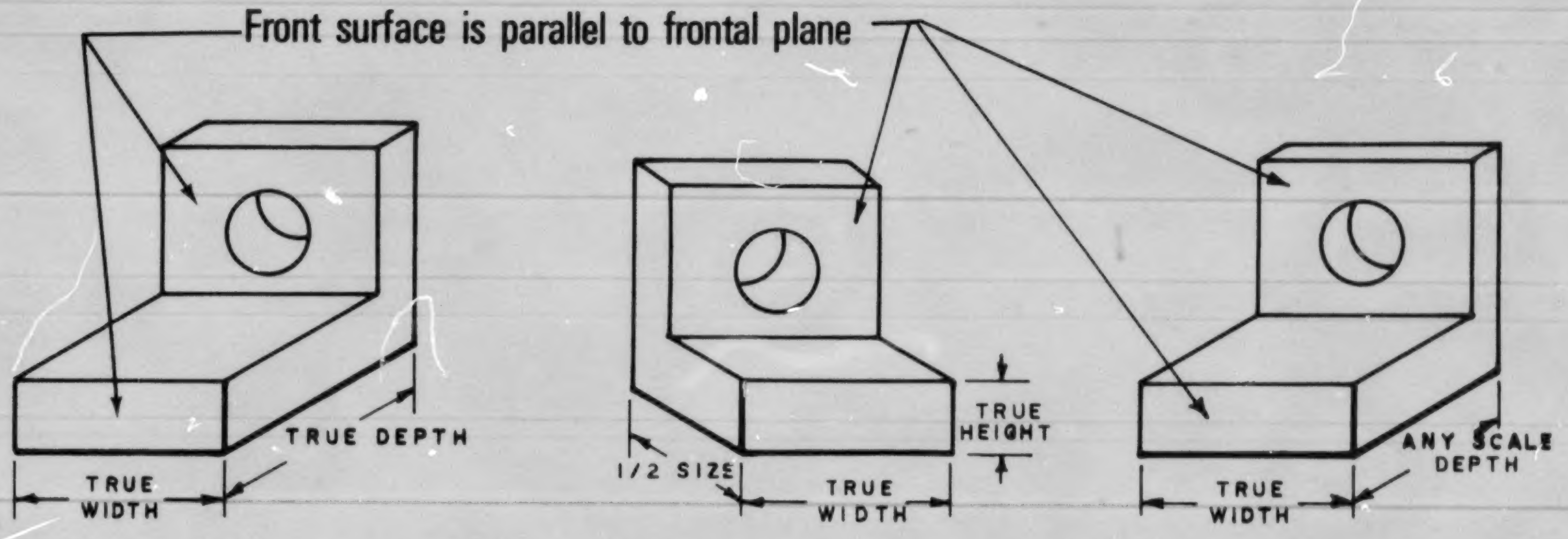
  B. Unidirectional

INFORMATION SHEET

VIII. Rules in dimensioning an oblique drawing

- A. Dimensions must be put in by the aligned method or the unidirectional method
- B. Use guidelines for all notes
- C. Dimension and extension lines should be parallel to the plane being dimensioned
- D. Keep dimensions off object if possible
- E. Dimensions should all be made to visible surfaces if possible
- F. Dimension size of holes with notes and leaders
- G. Keep dimension lines evenly spaced and not crowding the drawing

Types of Oblique Drawings

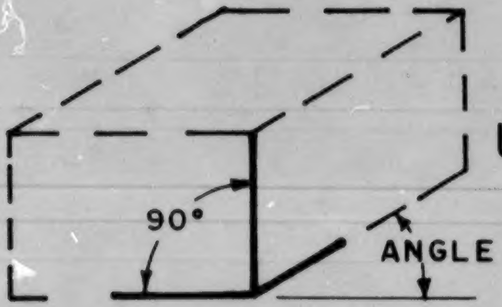

Front surface is parallel to frontal plane
TRUE DEPTH
TRUE WIDTH
1/2 SIZE
TRUE WIDTH
TRUE HEIGHT
ANY SCALE DEPTH
TRUE WIDTH

Cavalier

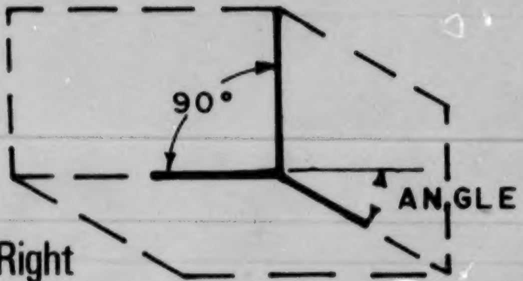
Cabinet

General

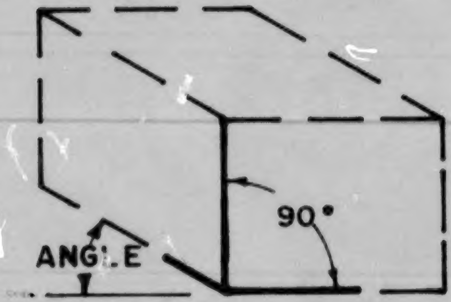
Positions of Oblique Axis



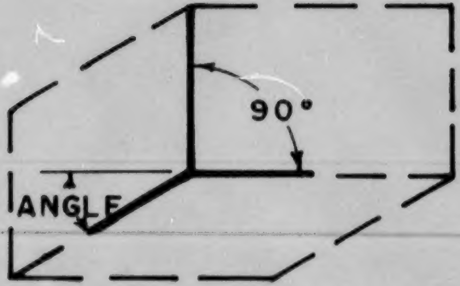
Up to Right



Down to Right



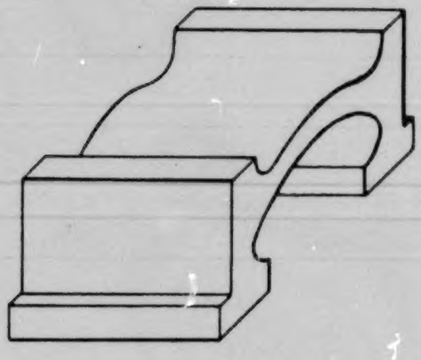
Up to Left



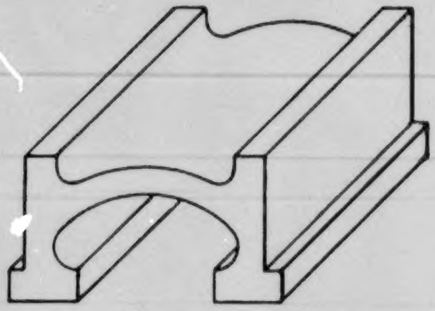
Down to Left

Depth angle can be at any angle but usually between 30° and 60°

Common Errors on Oblique Drawings

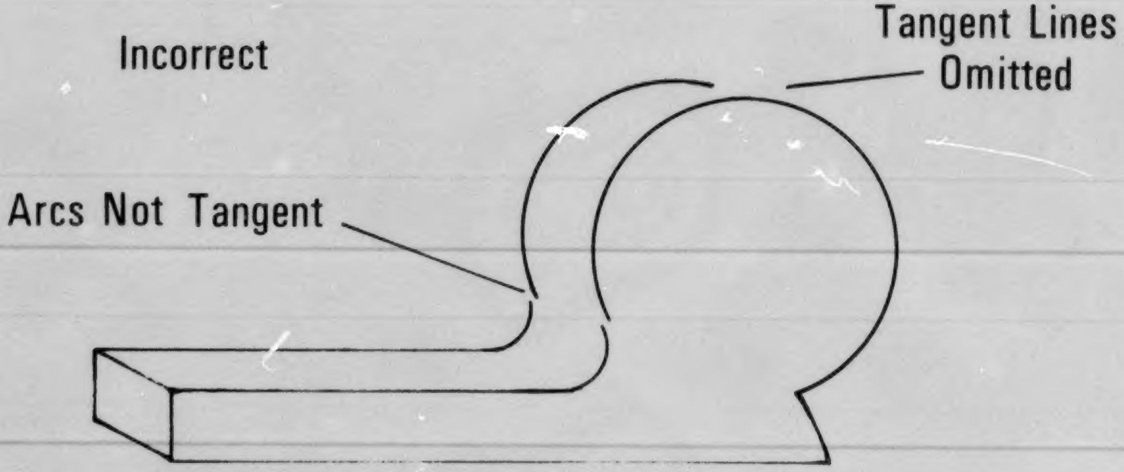


Wrong Axis Selected

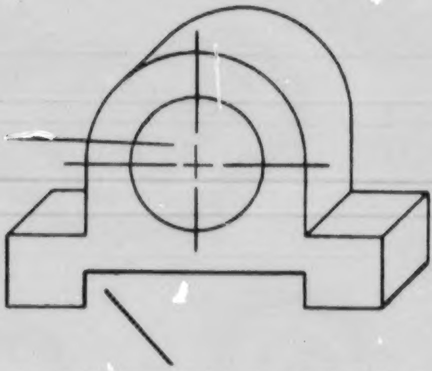


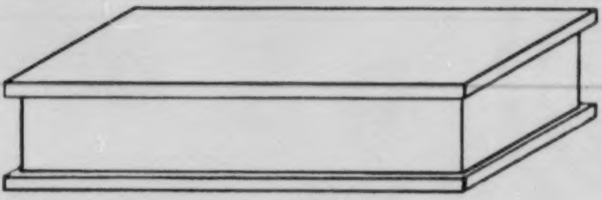
Correct

Incorrect

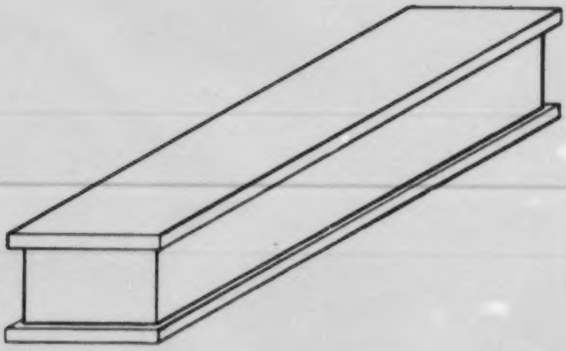

Tangent Lines Omitted
Arcs Not Tangent

Common Errors on Oblique Drawings (Continued)


Rear Circle Omitted
Key Line Missing

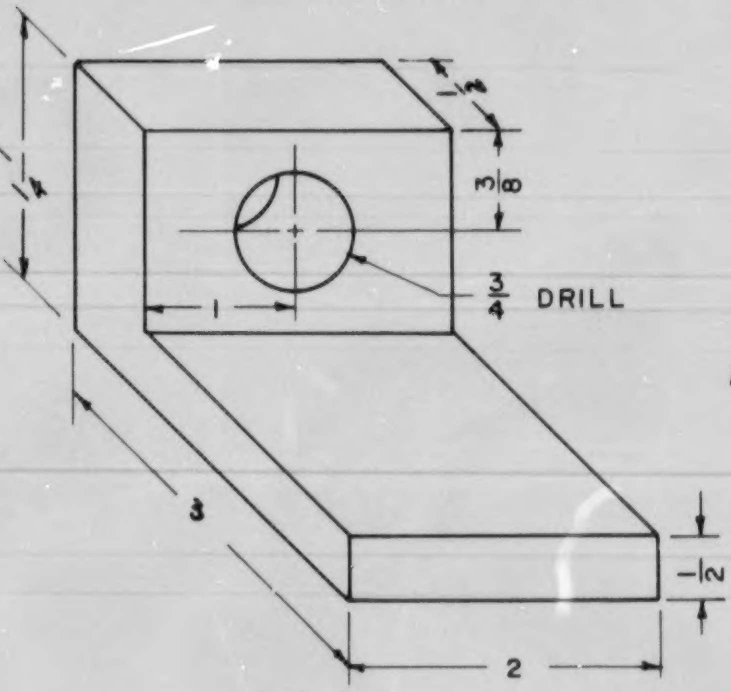


Correct

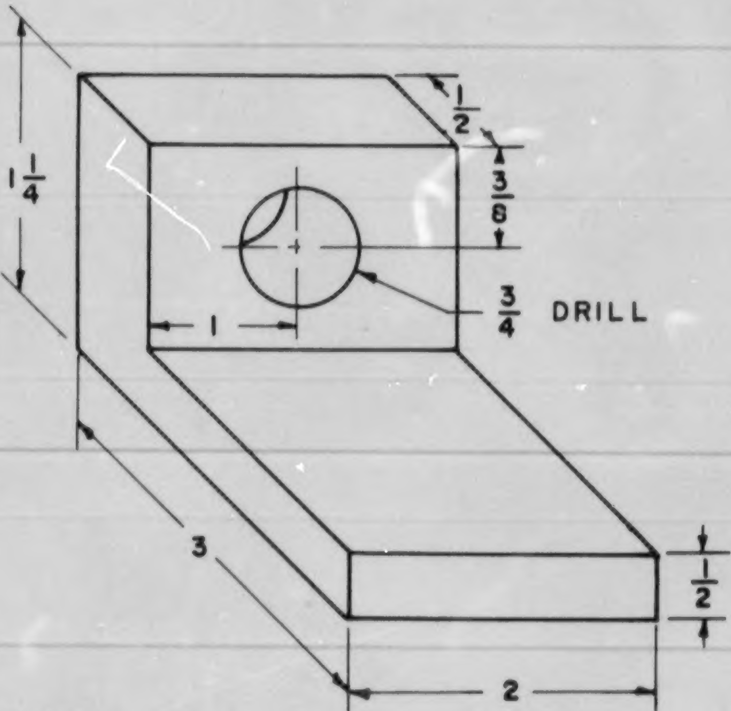


Incorrect

Methods of Dimensioning Obliques


1 1/4
1/2
3/8
3/4 DRILL
1
3
1/2
2

Aligned


1 1/4
1/2
3/8
3/4 DRILL
1
3
1/2
2

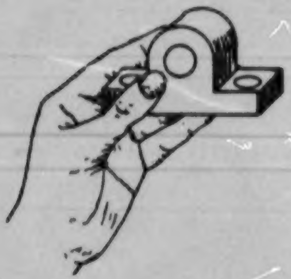
Unidirectional

OBLIQUE
UNIT X

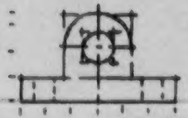
ASSIGNMENT SHEET #1--SKETCH AN OBLIQUE

Premise: An oblique can be sketched by using the procedure in the following example.

Example:

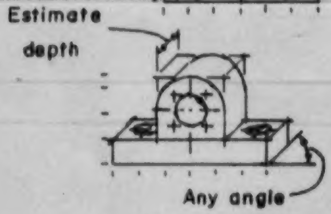


1. Take the object and block in a front view

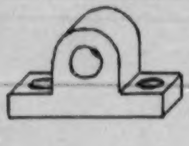


2. Next, the receding lines should be drawn parallel to each other at a 45° angle or any convenient angle and the lines should be cut so the depth looks correct

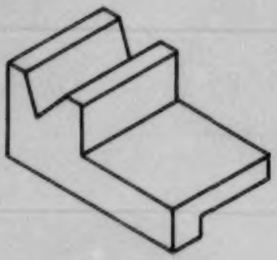
   (NOTE: If receding lines are 1/2 their full length, the sketch is a cabinet sketch; if the receding lines are full length, the sketch is a cavalier sketch.)



3. Use an artgum eraser to dim construction lines and darken in visible lines



Directions: Make a full size oblique sketch of the following object.



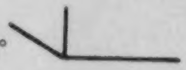
OBLIQUE
UNIT X

ASSIGNMENT SHEET #2--CONSTRUCT AN OBLIQUE DRAWING BY BOX METHOD

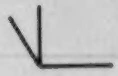
Premise: An oblique can be constructed by box method using the procedure in the following example. The same procedure is used for cavalier, cabinet, and general obliques.

Example:

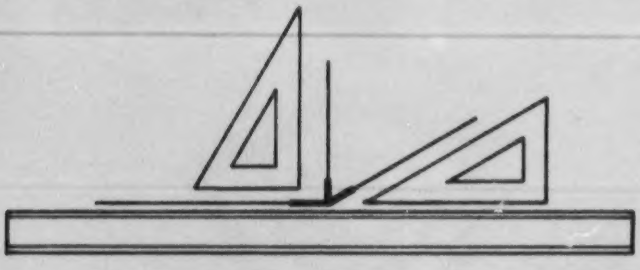
1. Attach sheet to drawing surface in alignment with working edge using a parallel bar or drafting machine
2. Select either of the following positions of oblique axis lines
   - a. 45°



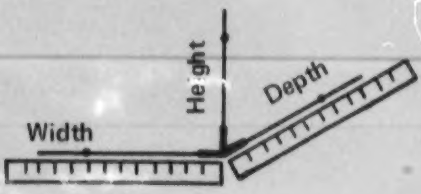
   - b. 60°



3. Locate axis lines on drawing media so that contours and circles are in best position

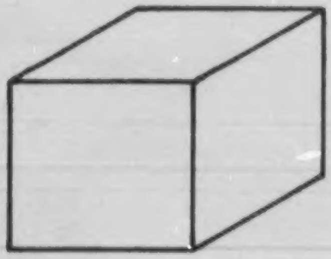


4. Measure overall width, depth, and height on these projected axis lines

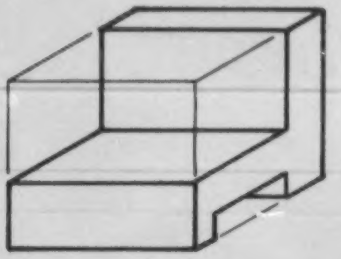


ASSIGNMENT SHEET #2

5. Complete box parallel to main axis lines



6. At this point details can be added to complete shape of object



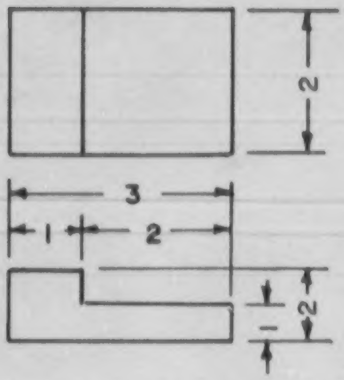
Directions: Construct a cavalier oblique drawing of a box with the following dimensions: H = 1", D = 2", W = 3". Use the axis line shown by instructor.

Problem A:

ASSIGNMENT SHEET #2

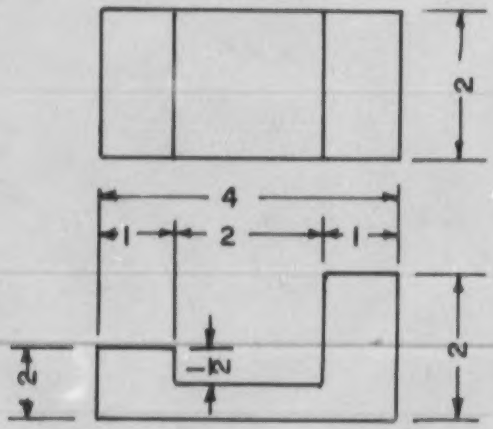
Directions: Construct a cabinet oblique drawing of the following object. Depth axis is up to right 45°.

Problem B:



Directions: Construct a general oblique drawing of the following object. Depth axis is up to left 45° and 3/8" scale.

Problem C:



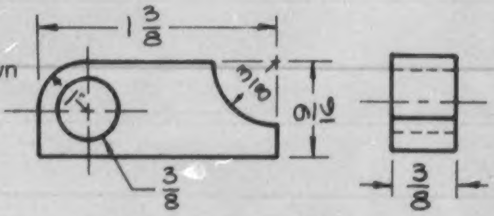
OBLIQUE
UNIT X

ASSIGNMENT SHEET #-3-MEASURE IN OBLIQUE

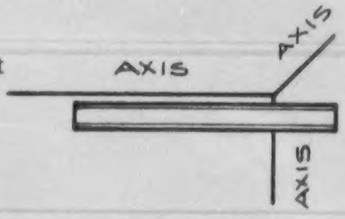
Premise: An oblique can be constructed with measurements by using the procedure in the following example.

Example:

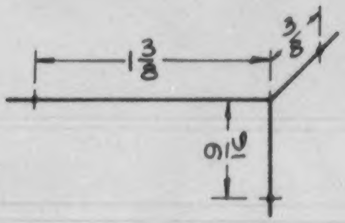
1. Sketch necessary views of object to be drawn


1 3/8
3/16
9/16
3/8
3/8

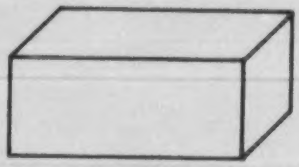
2. Lay out axis lines selecting axis best for object


AXIS
AXIS
AXIS

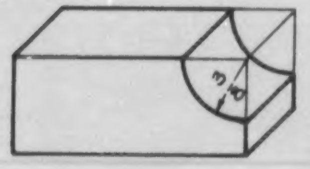
3. Measure dimensions on axis lines



4. Box in object

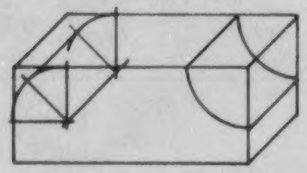


5. Add arc at right side of box

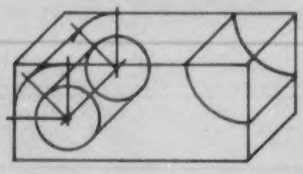


ASSIGNMENT SHEET #3

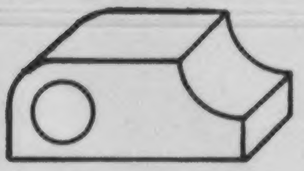
6. Add arcs at left side of box



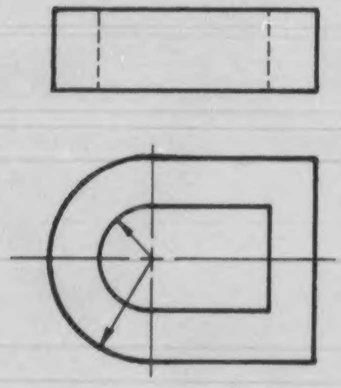
7. Add circle in object



8. Darken visible lines



Directions: Construct the object below in cavalier. Depth axis is up to right 45°.

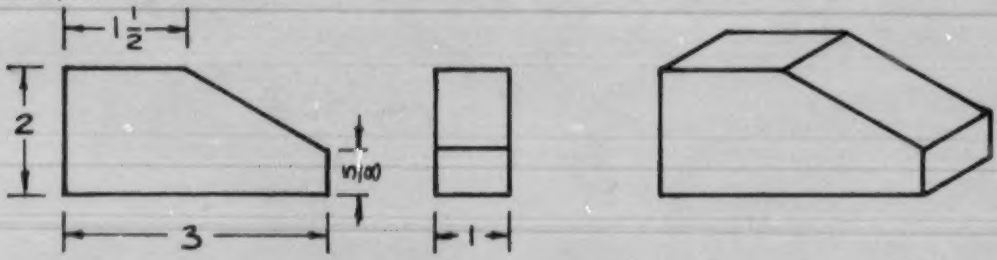


OBLIQUE
UNIT X

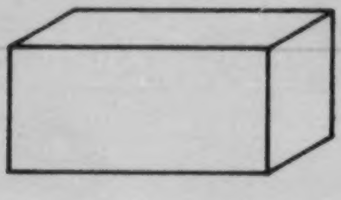
ASSIGNMENT SHEET #4--CONSTRUCT ANGLES ON AN OBLIQUE OBJECT

Premise: Angles on an oblique object can be constructed by using the procedure in the following example.

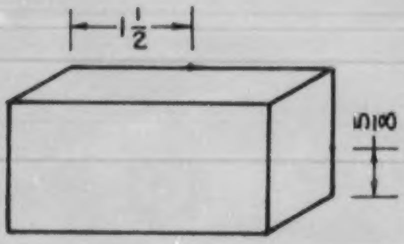
Example:



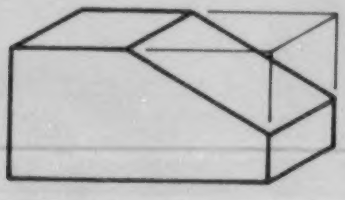
1. Box in overall dimensions of the object in oblique



2. Use dividers or scale to lay out offset dimensions of angle

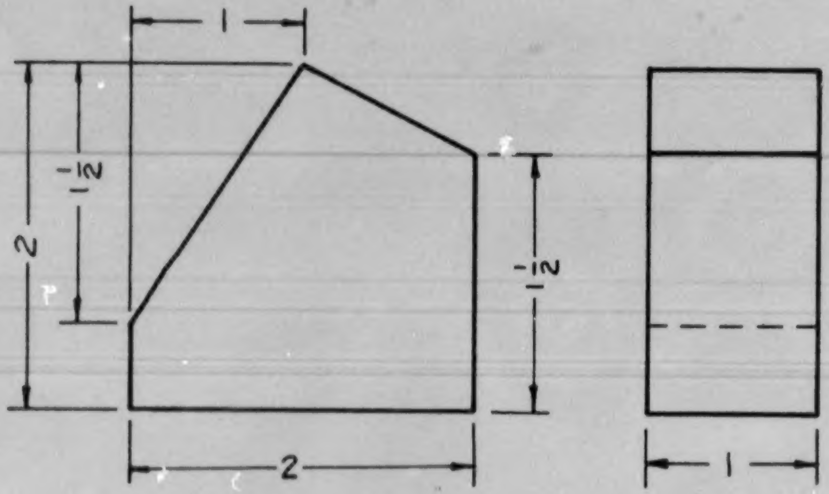


3. Connect points and complete the shape of the object



ASSIGNMENT SHEET #4

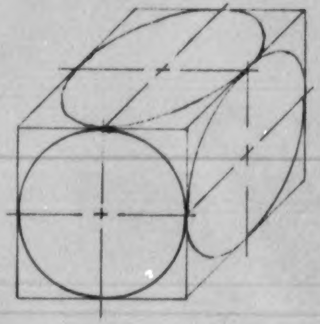
Directions: Draw the following object in cavalier. Depth axis is up to left 45°.


1
$1\frac{1}{2}$
2
$1\frac{1}{2}$
2
1

OBLIQUE
UNIT X

ASSIGNMENT SHEET #5–CONSTRUCT OBLIQUE CIRCLES

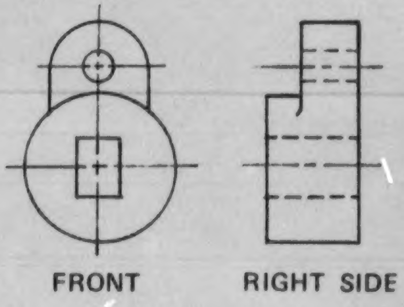
Premise: A circle can appear in any one of the three planes shown at right. In the front plane the circle is drawn as a true circle with the compass. The other two planes are drawn using the four-center ellipse method which makes drawing easier and more legible. Oblique circles can be constructed by using the procedure in the following example.



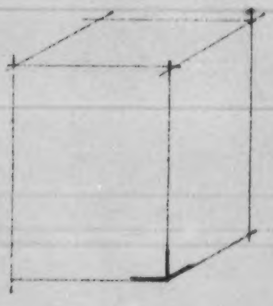
Example:

1. With this object all circles can be drawn from the front plane; determine depths, heights, and diameters of circles and arcs

   (NOTE: All circles are either in the front plane or parallel to the front plane.)

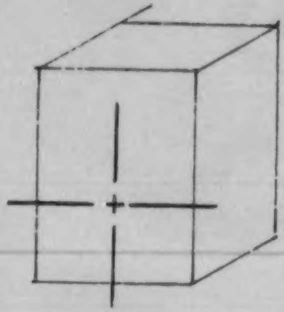


2. Box in overall shape

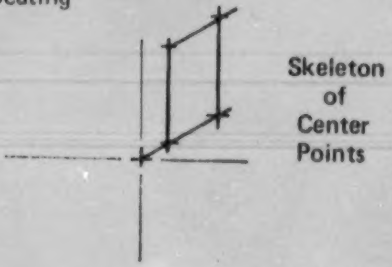


ASSIGNMENT SHEET #5

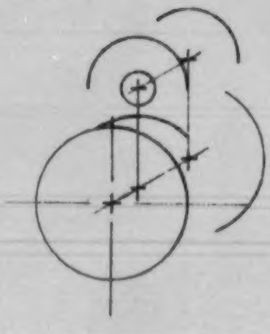
3. Locate center point of circle in front surface



4. Lay out skeleton framework of object by locating circle center points



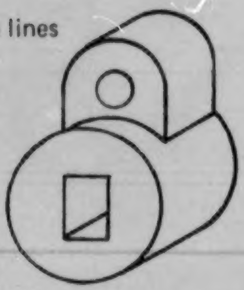
5. Use center points to draw in circles and arcs using circle template or compass



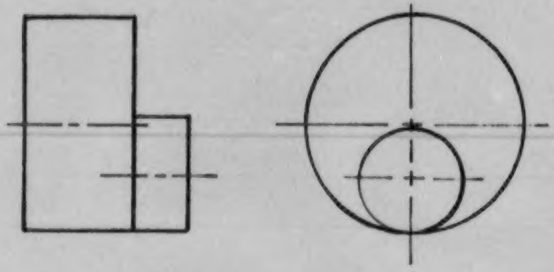
6. Put in lines tangent to circle arcs

ASSIGNMENT SHEET #5

7. Add other features and darken lines



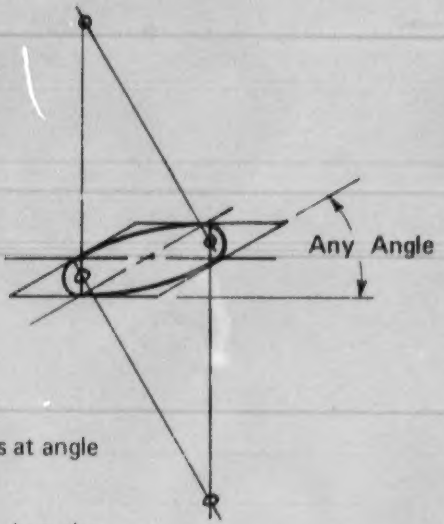
Directions: Construct a cavalier drawing of the following object. Depth axis is up to left 45°.



OBLIQUE
UNIT X

ASSIGNMENT SHEET #6--CONSTRUCT OBLIQUE CIRCLES IN DEPTH PLANE

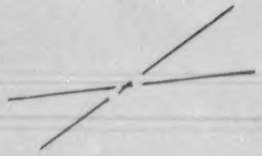
Premise: Oblique circles in depth planes can be constructed by using the procedure in the following example. In oblique drawings the depth angle can be at any angle, usually 30°, 60°, or 45°.



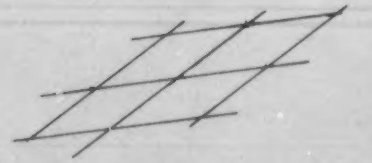
Example:

1. Locate center of circle and lay out center lines at angle desired

   (NOTE: A 45° will be used in this example, but the method is the same for all angles.)

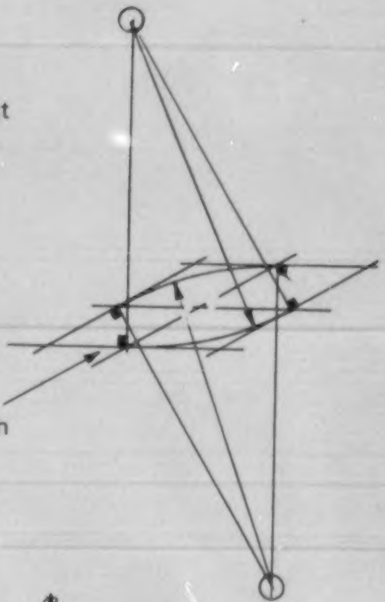


2. Mark off radius points and box in, making sides parallel to center lines



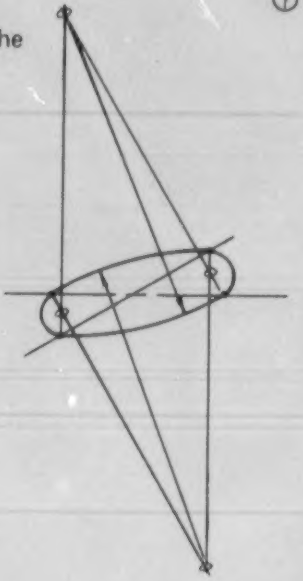
ASSIGNMENT SHEET #6

3. Erect perpendicular bisectors to each side until lines intersect outside box; use these points as radius

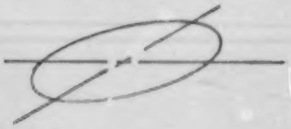


(NOTE: Little box indicates lines perpendicular to each other.)

4. Swing arc from points where these lines intersect inside the box



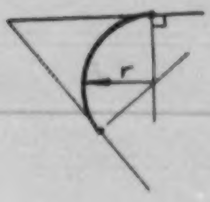
5. Darken circle ellipse and erase construction lines



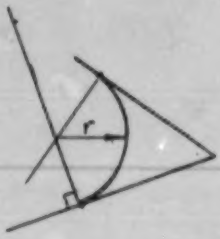
(NOTE: The same procedure is used for an ellipse on the side plane.)

ASSIGNMENT SHEET #6

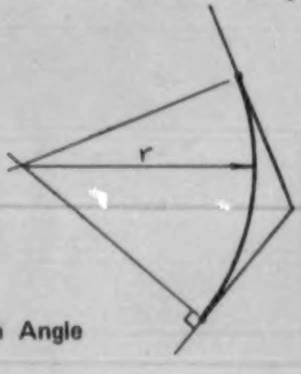
6. The same procedure applies to arcs; project perpendicular lines from the radius tangent points



Closed Angle



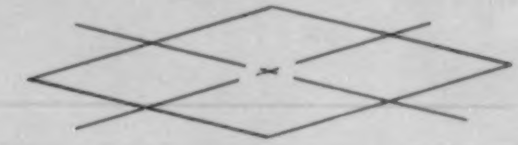
Closed Angle



Open Angle

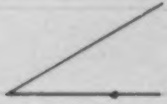
Directions: Draw an oblique circle in the box below.

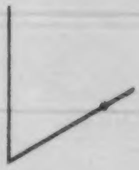
Problem A:

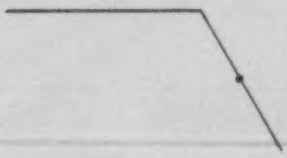


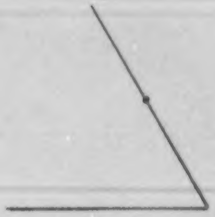
Directions: Use points indicated to draw arcs in angles below.

Problem B:









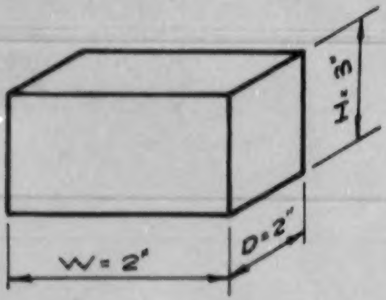
OBLIQUE
UNIT X

ASSIGNMENT SHEET #7--CONSTRUCT AN OBLIQUE DRAWING IN THE CENTER OF A DRAWING SPACE

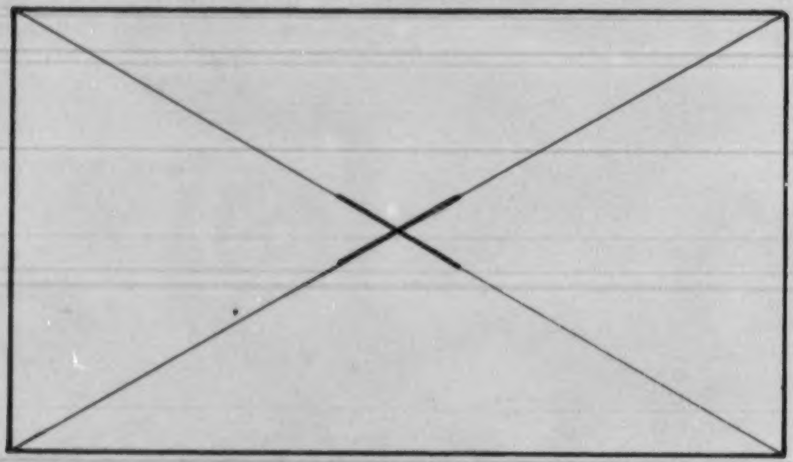
Premise: It is important that oblique drawings be located somewhere near the center of the drawing space that is available to allow room for dimensions, notes, and to add to the neatness of the object. An oblique drawing can be constructed in the center of the drawing space by using the procedure in the following example.

Example:

1. Box in an oblique sketch of the overall dimensions of the object to be drawn

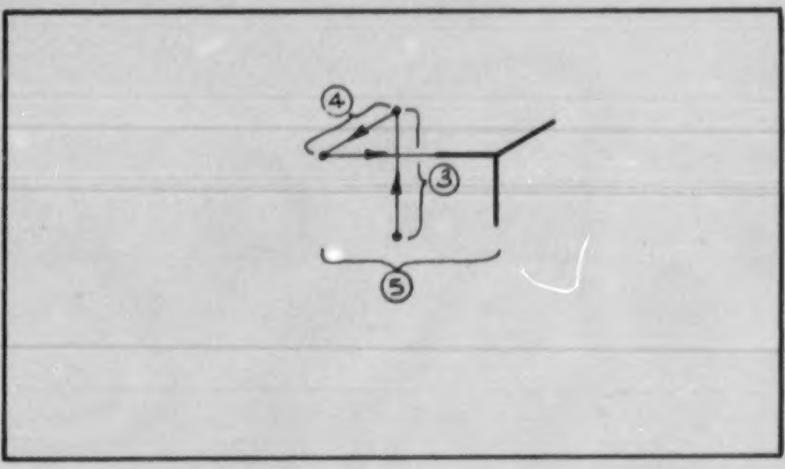


2. Find center of drawing space by using diagonals from corners

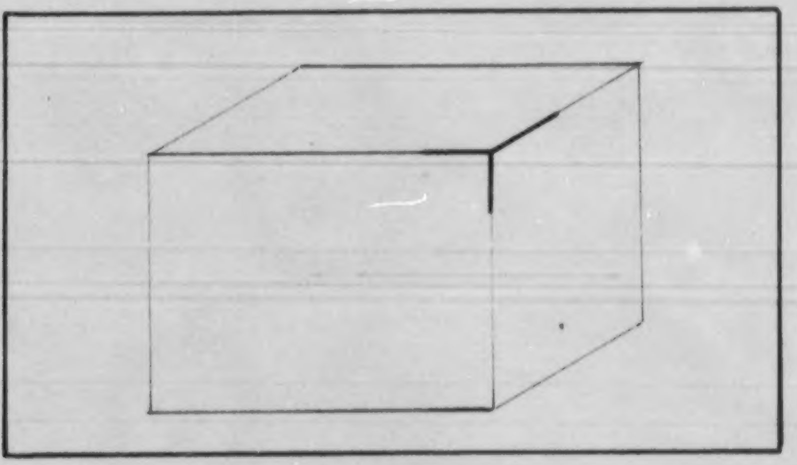


ASSIGNMENT SHEET #7

3. From the center of the work area, measure vertically 1/2 the height of the object (1 1/2" in this example)
4. At some angle down and to the left, measure 1/2 the depth of the object (1" in this example)
5. At a horizontal direction to the right, measure 1/2 the length of the object (2" in this example)



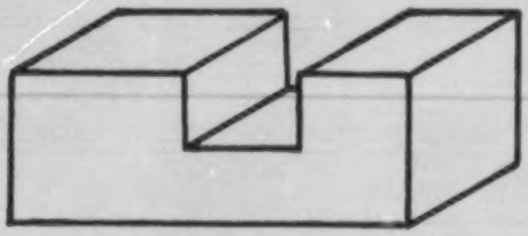
6. Complete the shape of the box



ASSIGNMENT SHEET #7

Directions: Center and construct the following oblique in the space below. Use dividers and drafting machine to transfer dimensions.

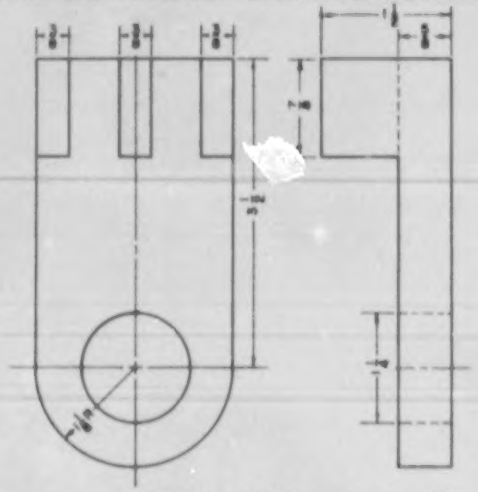
Problem A:



ASSIGNMENT SHEET #7

Directions: Center and construct a cavalier drawing of the following object on "A" size vellum with standard border and title block. Omit dimensions and erase construction lines.

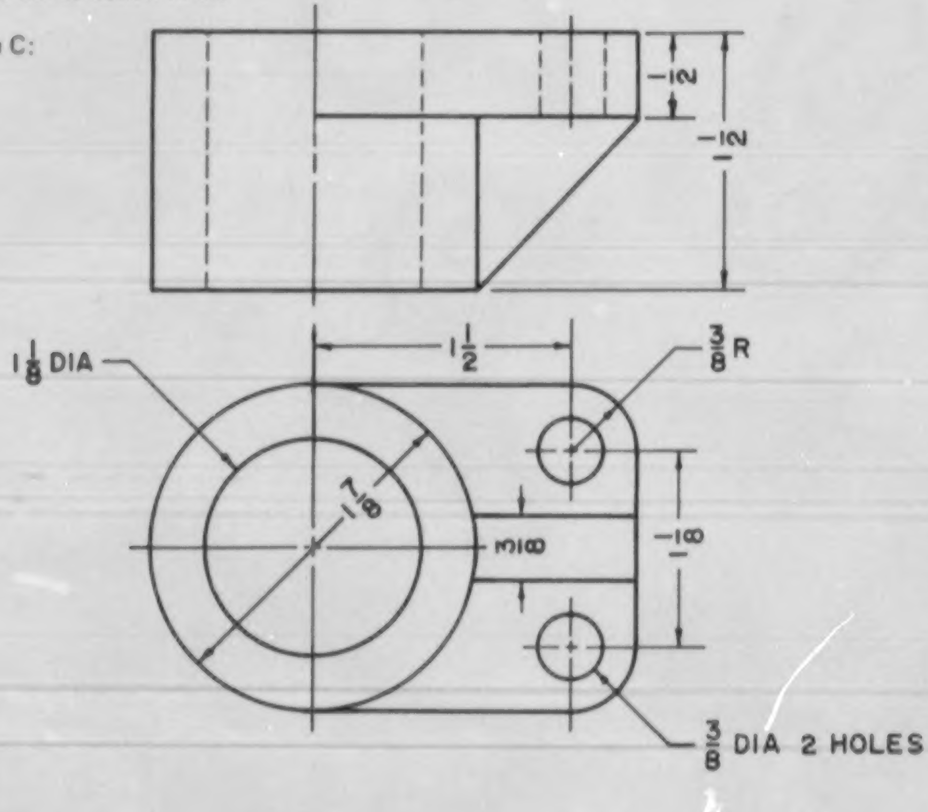
Problem B:



$\frac{3}{8}$
$\frac{3}{8}$
$\frac{3}{8}$
$\frac{3}{8}$
$\frac{7}{8}$
$3\frac{1}{2}$
$1\frac{1}{4}$

Directions: Center and construct a cabinet drawing of the following object on "A" size vellum with standard border and title block. Construct 45° up to right. Dimension drawing and erase construction lines.

Problem C:

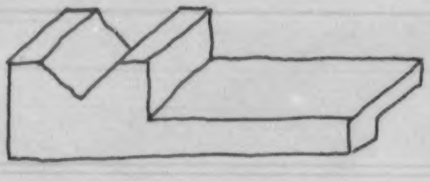


$\frac{1}{2}$
$1\frac{1}{2}$
$1\frac{1}{8}$ DIA
$1\frac{1}{2}$
$\frac{3}{8}$R
$1\frac{7}{8}$
$\frac{3}{8}$
$1\frac{1}{8}$
$\frac{3}{8}$ DIA 2 HOLES

OBLIQUE
UNIT X

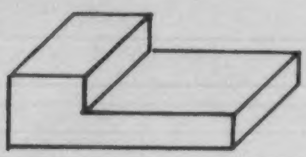
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

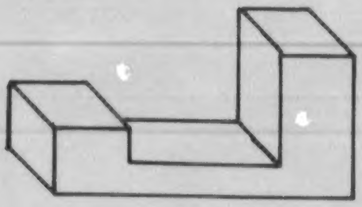


Assignment Sheet #2

B.

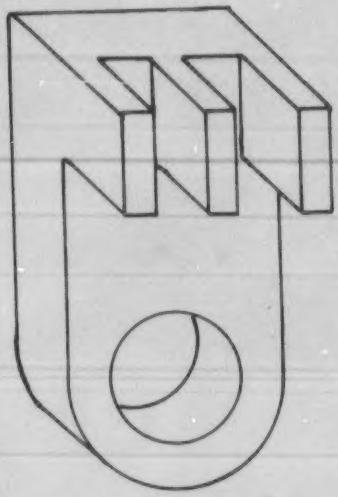


C.



Assignment Sheet #7

B.



OBLIQUE
UNIT X

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. To extend from point to another

_____b. Suggesting a picture or mental image

_____c. To appear shorter to the eye than it actually is

_____d. The lines used to represent where planes come together

_____e. The lines that run parallel with one of the oblique axis lines

_____f. The lines that do not run parallel to one of the oblique axis lines

_____g. A foreshortened circle with a major and minor diameter

_____h. A type of oblique drawing with all axis lines drawn true length

_____i. A type of oblique drawing with the depth axis drawn half scale and the other axis lines drawn true length

_____j. A type of oblique drawing with the depth axis drawn at any scale

_____k. A type of pictorial drawing with front plane true size and parallel to frontal plane, the other two at any angle to the front

1. General
2. Cavalier
3. Oblique
4. Cabinet
5. Foreshortened
6. Axis lines
7. Project
8. Oblique lines
9. Non-oblique lines
10. Ellipse
11. Pictorial

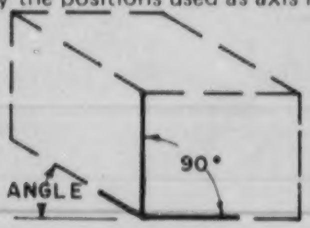
2. List three types of oblique drawings.

a. ______________________________

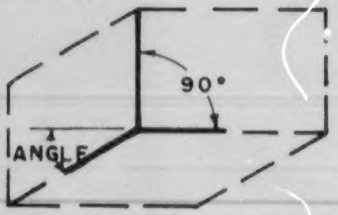
b. ______________________________

c. ______________________________

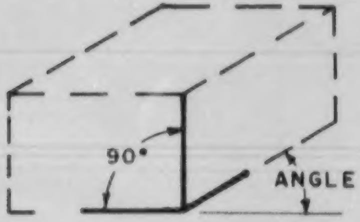
3. Identify the positions used as axis lines on oblique drawings.



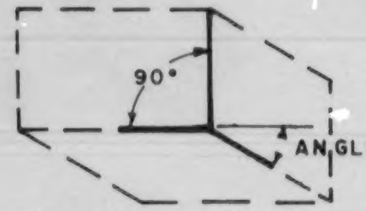
a. ______________________



b. ______________________



c. ______________________



d. ______________________

4. Name the two most common positions used as axis lines.

a. ______________________

b. ______________________

5. Select true statements concerning rules in constructing an oblique drawing by placing an "X" in the appropriate blanks.

_____a. All measurements are made parallel to the main axis edges of the oblique axis lines

_____b. Angles are measured by coordinate offsets

_____c. Hidden lines are always used on oblique drawings

_____d. It isn't necessary to center an oblique drawing

_____e. The concentric circle method is always used for drawing oblique circles

_____f. Always construct arcs before boxing in a circle

_____g. Face circles and contours toward the top plane of an oblique drawing, rather than the front

_____h. Draw long objects with the long axis perpendicular to the line of sight

_____i. Keep all arcs and lines tangent to each other

_____j. Include the rear ellipse or circle of a hole if it is visible

6. Match common errors made in oblique drawing below with their correct drawings.

_____a. Wrong axis selected

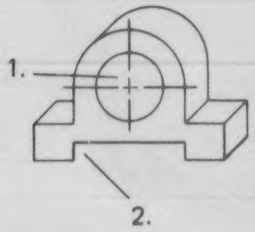
_____b. Arcs not tangent

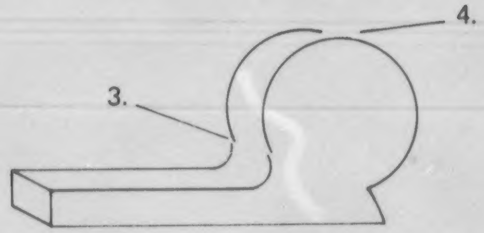
_____c. Line missing

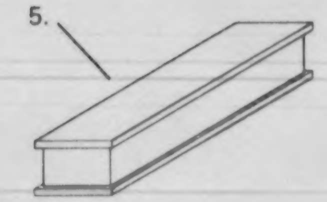
_____d. Rear circle or ellipse omitted

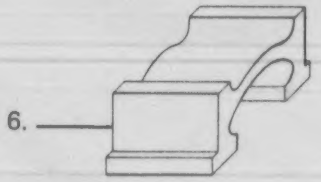
_____e. Tangent lines omitted

_____f. Plane with the longest dimension not in front plane









7. List two methods of dimensioning an oblique.

a. ____________________

b. ____________________

8. Select true statements concerning rules in dimensioning an oblique drawing by placing an "X" in the appropriate blanks.

_____a. Dimensions must always be put in by the unidirectional method

_____b. Use guidelines only for dimensions

_____c. Dimension and extension lines should be parallel to the plane being dimensioned ______d. Keep dimensions on object

______e. Dimensions should be made to hidden surfaces

______f. Dimension size of holes with notes and leaders

______g. Keep dimension lines evenly spaced and not crowding the drawing

9. Demonstrate the ability to:

   a. Sketch an oblique.

   b. Construct an oblique drawing by box method.

   c. Measure in oblique.

   d. Construct angles on an oblique object.

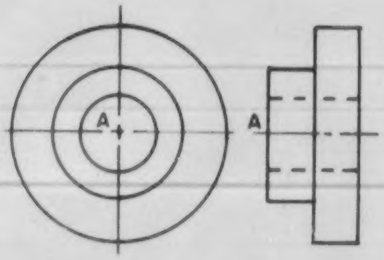
   e. Construct oblique circles.

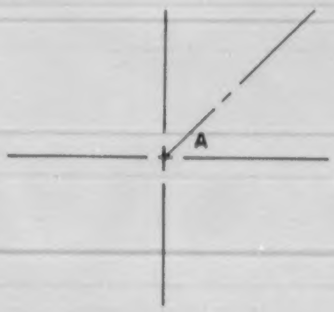
   f. Construct oblique circles in depth plane.

   g. Construct an oblique drawing in the center of a drawing space.

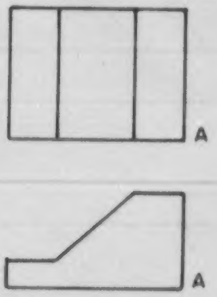
   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

10. Construct a cavalier oblique drawing of the object below in the space at right. Begin with point A and double dimensions with dividers.





11. Construct a cabinet oblique drawing of the object below in the space at right. Begin with point A and double dimensions with dividers.



OBLIQUE
UNIT X

ANSWERS TO TEST

1. a. 7
   b. 11
   c. 5
   d. 6
   e. 8
   f. 9
   g. 10
   h. 2
   i. 4
   j. 1
   k. 3

2. a. Cabinet
   b. Cavalier
   c. General

3. a. Up to left
   b. Down to left
   c. Up to right
   d. Down to right

4. a. Up to left
   b. Up to right

5. a, b, h, i, j

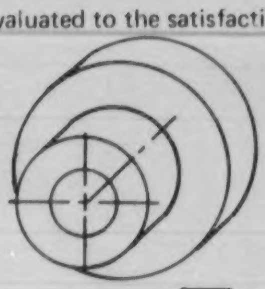
6. a. 6
   b. 3
   c. 2
   d. 1
   e. 4
   f. 5

7. a. Aligned
   b. Unidirectional

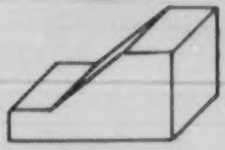
8. c, f, g

9. Evaluated to the satisfaction of the instructor

10.



11.



PERSPECTIVE
UNIT XI

UNIT OBJECTIVE

After completion of this unit, the student should be able to list perspective types, identify views, list types of equipment, and select the uses of perspectives. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to perspective with their correct definitions
2. List three types of perspectives.
3. Identify the types of perspective views.
4. List three types of perspective equipment.
5. List the use of each type of perspective.
6. Identify the lines and points in a two point perspective.
7. Select true statements concerning the steps in sketching a one point perspective.
8. Select true statements concerning the steps in sketching a two point perspective.
9. Match terms with their correct letter designations.
10. Demonstrate the ability to:
    a. Sketch a one point perspective.
    b. Sketch a two point perspective.
    c. Construct a one point perspective.
    d. Construct a two point perspective.
    e. Construct curves in a perspective.

PERSPECTIVE
UNIT XI

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information and assignment sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Have students do a perspective for building trades program.

VII. Visit architectural delineator's office.

VIII. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  A. Objective sheet
  B. Information sheet
  C. Transparency masters
    1. TM 1--Types of Perspectives
    2. TM 2--Perspective Views
    3. TM 3--Perspective Equipment
    4. TM 4--Two Point Perspective
       Overlay 4A--Two Point Perspective
    5. TM 5--Perspective Terms
    6. TM 6--One Point and Two Point Perspective Sketching
  D. Assignment sheets
    1. Assignment Sheet #1--Sketch a One Point Perspective
    2. Assignment Sheet #2--Sketch a Two Point Perspective
    3. Assignment Sheet #3--Construct a One Point Perspective

4. Assignment Sheet #4--Construct a Two Point Perspective

5. Assignment Sheet #5--Construct Curves in a Perspective

E. Test

F. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry*. South Holland, IL 60473: Goodheart-Willcox Co., Inc., 1974.

B. Goodhan, Jack J. and Jack J. Hayslefft. *Architectural Drawing and Planning*. St. Louis, MO: Gregg Division/McGraw-Hill Book Co., 1979.

C. Jensen, Cecil and Jay Helsel. *Engineering Drawing and Design*. St. Louis, MO: Gregg Division/McGraw-Hill Book Co., 1979.

PERSPECTIVE
UNIT XI

INFORMATION SHEET

I. Terms and definitions

A. Perspective--Pictorial drawing made by the intersection of the picture plane with lines of sight meeting from points on the object to the point of sight

B. Delineation--Process of drawing pictures for display as opposed to making detailed working drawings

C. One point perspective--Has only one vanishing point and the frontal plane of the object is parallel to the picture plane

D. Two point perspective--Has two vanishing points

E. Three point perspective--Has three vanishing points

F. Perspective grid--Graph oriented method for making accurate perspectives without having to establish vanishing points and measure lines

G. Perspective board--Has variety of scales and permits direct reading for layout of perspectives

H. Horizon line--Eye level of the person viewing the drawing and the line on which the vanishing points are located

I. Ground line--Bottom of the object being drawn

J. Picture plane--Projection plane of the plan view of the object being drawn

K. Station point--Assumed plan view point representing the observer's eye

L. Vanishing point--A point on the horizon at which receding parallel lines seem to meet

M. Vanishing lines--Lines of the object which meet on the vanishing points

N. Visual ray lines--Lines of sight from selected points on the object which pierce the picture plane on their way to the station point

O. Vertical measuring line--Part of the object closest to the person viewing the object on which true heights are measured

II. Types of perspectives (Transparency 1)

A. One point

B. Two point

C. Three point

INFORMATION SHEET

III. Types of perspective views (Transparency 2)

- A. Above horizon (Worm's eye view)
- B. Horizon (Man's eye view)
- C. Below horizon (Bird's eye view)

IV. Types of perspective equipment (Transparency 3)

- A. Grids
- B. Board
- C. Machine

V. Uses of each type of perspective

- A. One point--Represents the interior of an object
- B. Two point--Represents the exterior of an object
- C. Three point--Represents the exterior of an object

VI. Lines and points in a two point perspective (Transparency 4)

- A. Picture plane
- B. Horizon line
- C. Ground line
- D. Visual ray lines
- E. Station point
- F. Vanishing point left
- G. Vanishing point right
- H. Vertical measuring line
- I. Vanishing lines

VII. Steps in sketching a one point perspective (Transparency 5)

- A. Take the object, block in a front view, and select a vanishing point
- B. Sketch all receding lines to the vanishing point
- C. Estimate the depth of the object and sketch in the back portion of the object
- D. Use an artgum eraser to dim construction lines and darken in visible lines

INFORMATION SHEET

VIII. Steps in sketching a two point perspective (Transparency 5)

A. Sketch the front corner of the object in the true height

B. Locate the VPL and VPR on the horizon line

(NOTE: The distance to the horizon line may vary.)

C. Estimate the depth and width of the object

D. Block in all detail of remaining items

(NOTE: Most lines will go to either the VPL or VPR.)

E. Use an artgum eraser to dim construction lines and darken in visible lines

IX. Terms and their letter designations (Transparency 6)

A. Picture plane--PP

B. Horizon line--HL

C. Ground line--GL

D. Vanishing lines--VL

E. Visual ray lines--VRL

F. Vanishing points--VP

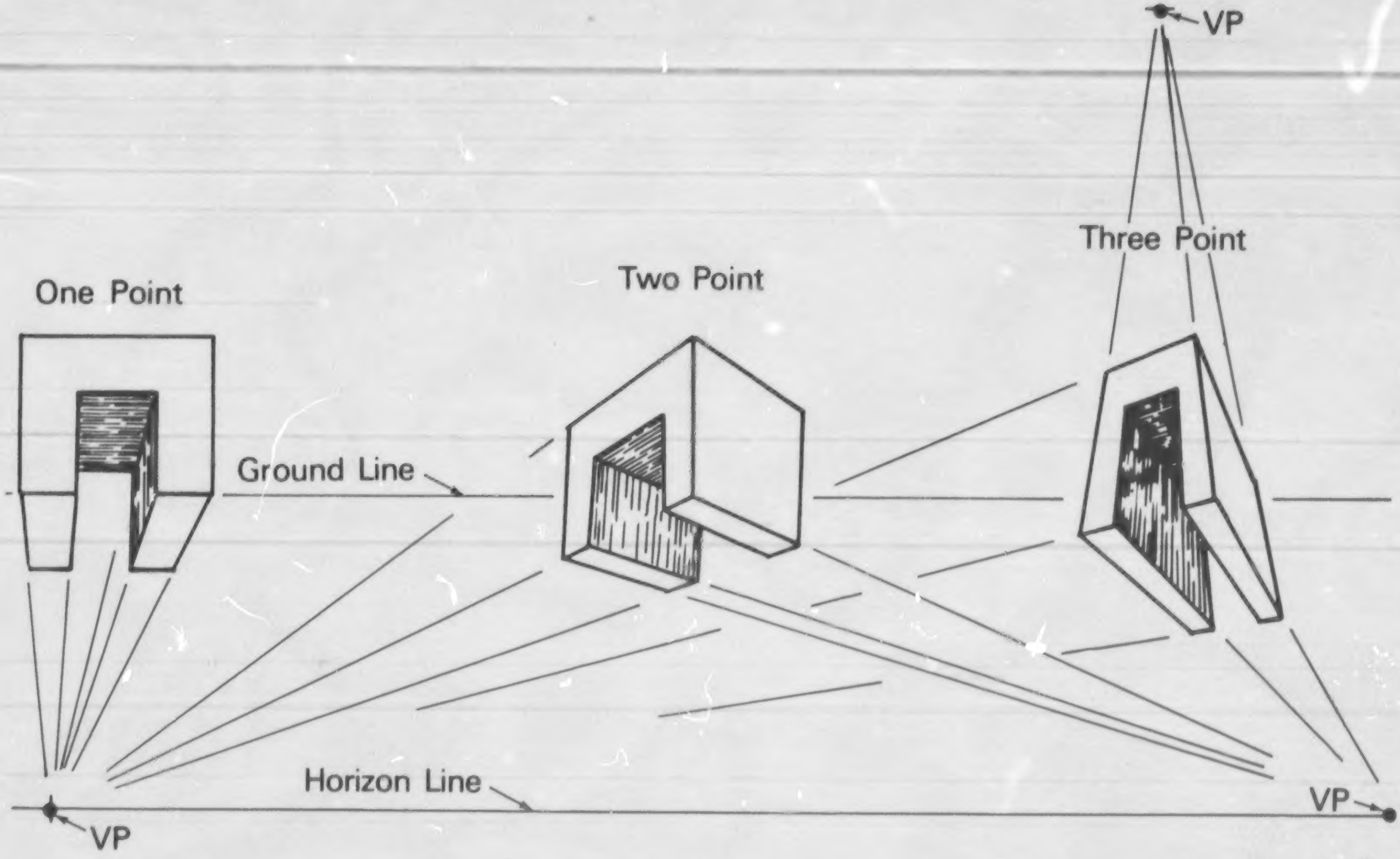
G. Vanishing point left--VPL

H. Vanishing point right--VPR

I. Vertical measuring line--VML

J. Station point--SP

Types of Perspectives


VP
Three Point
Two Point
One Point
Ground Line
Horizon Line
VP
VP

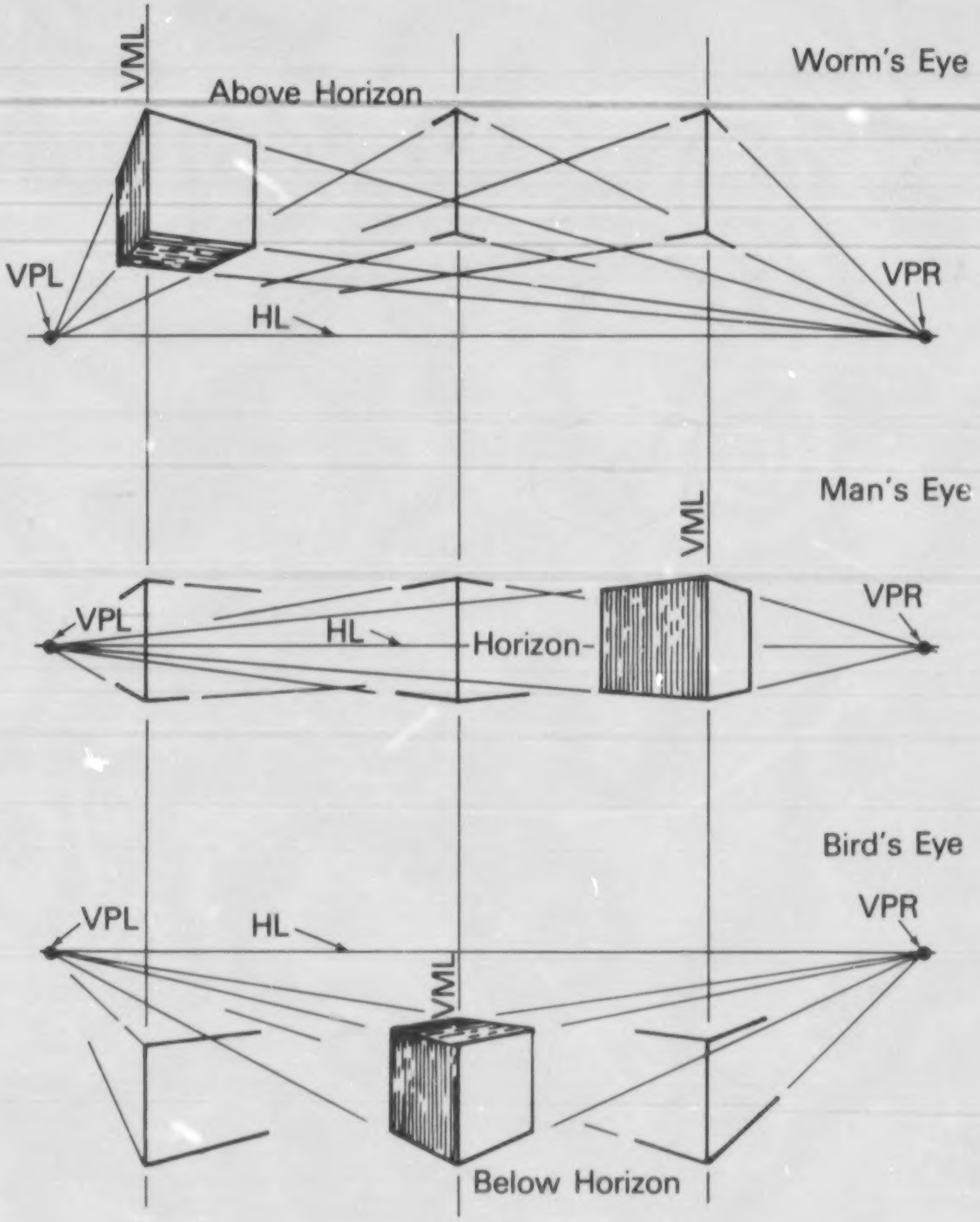
TM 1

735

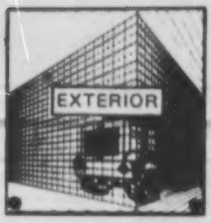
736

D II - 865

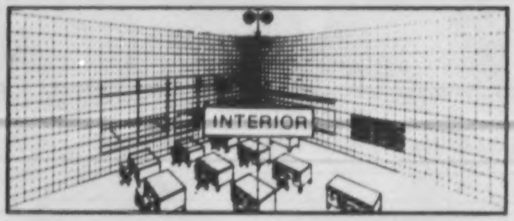
Perspective Views

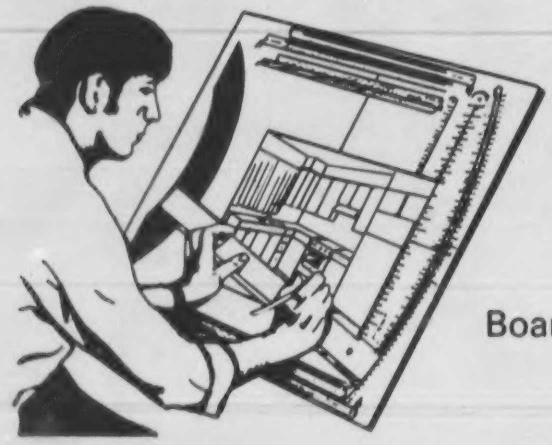

Worm's Eye
VML
Above Horizon
VPL
VPR
HL
Man's Eye
VML
VPL
VPR
HL
Horizon
Bird's Eye
VPL
HL
VPR
VML
Below Horizon

Perspective Equipment



Grids

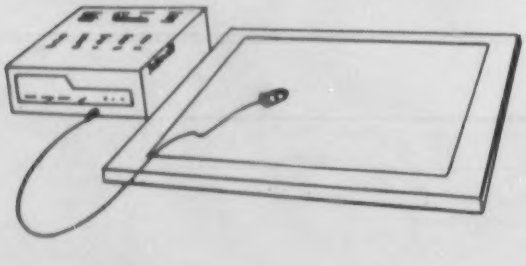




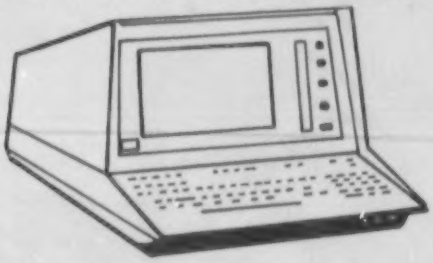
Board

Tektronix 4956 Digitizer

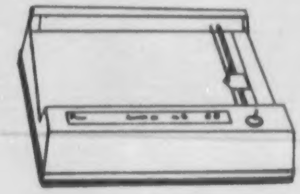
Machines



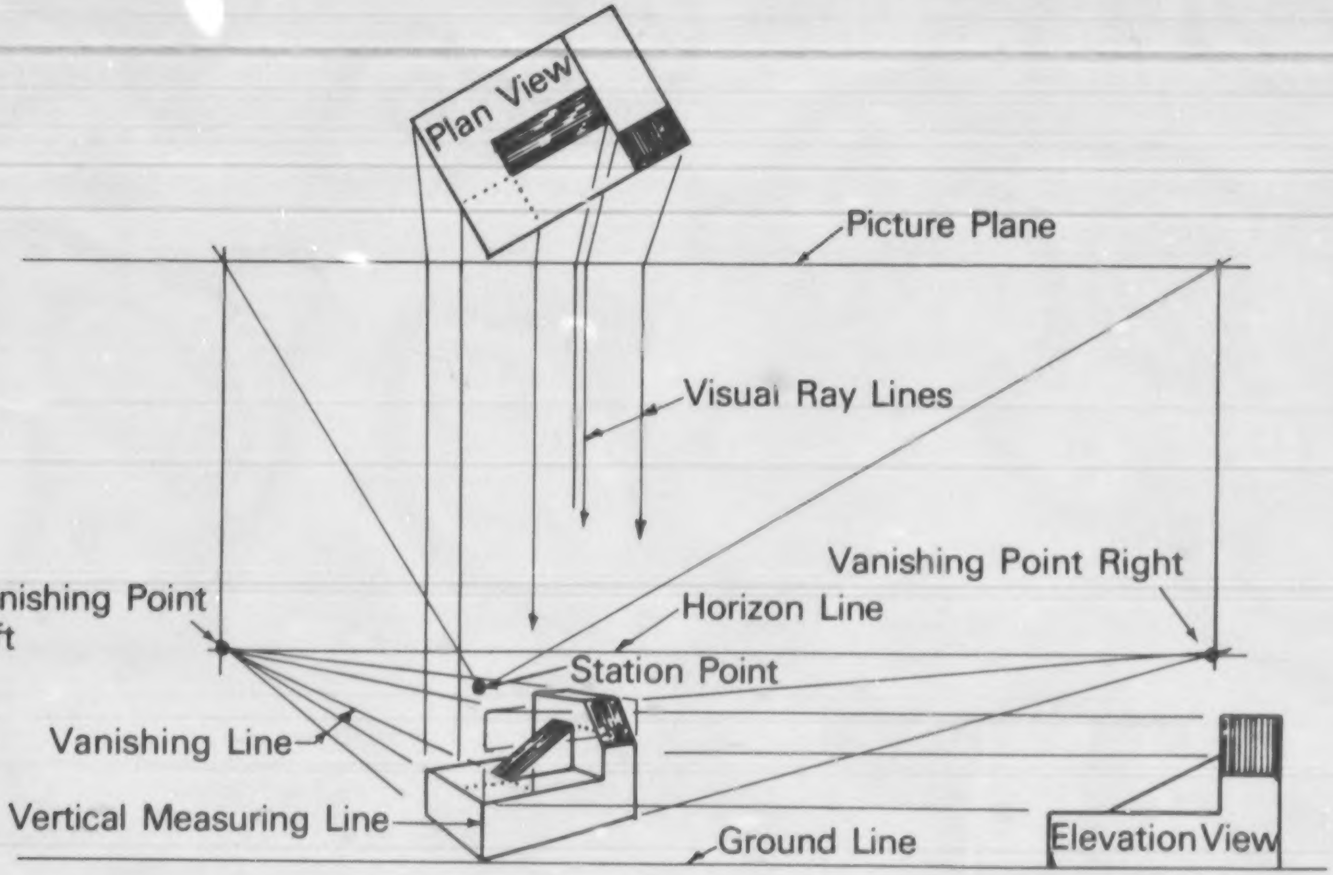
Tektronix 4051 Graphics System

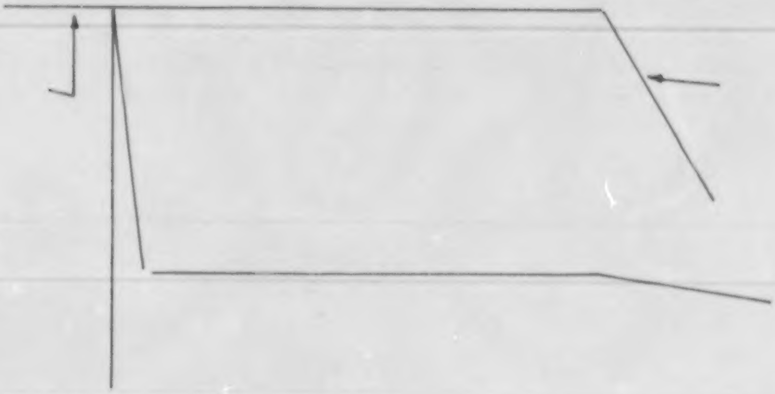


Tektronix 4662 Plotter



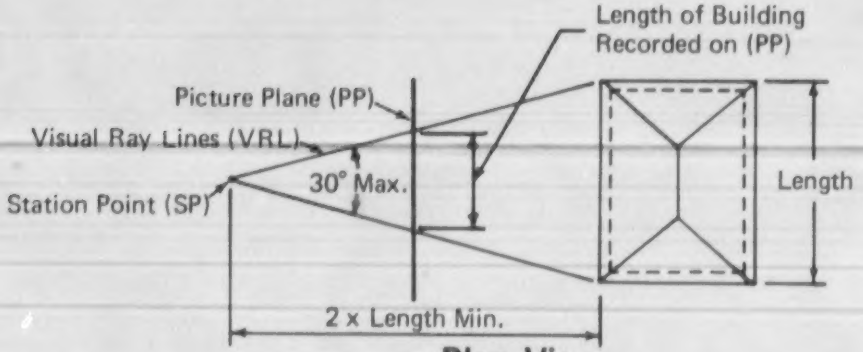
Two Point Perspective


Plan View
Picture Plane
Visual Ray Lines
Vanishing Point Right
Vanishing Point Left
Horizon Line
Station Point
Vanishing Line
Vertical Measuring Line
Ground Line
Elevation View

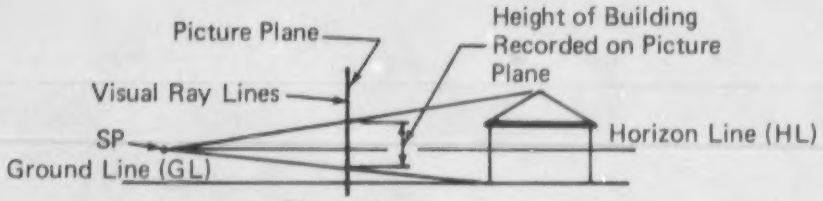


Overlay 4A

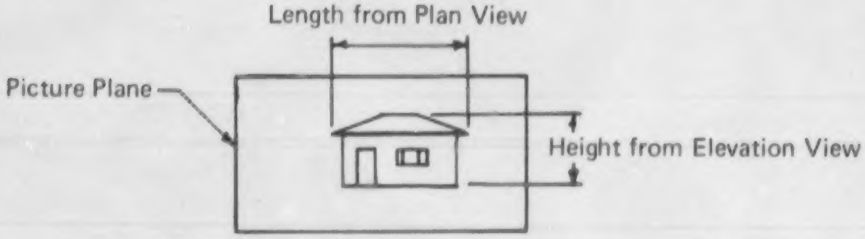
Perspective Terms


Length of Building
Recorded on (PP)
Picture Plane (PP)
Visual Ray Lines (VRL)
30° Max.
Station Point (SP)
Length
2 x Length Min.

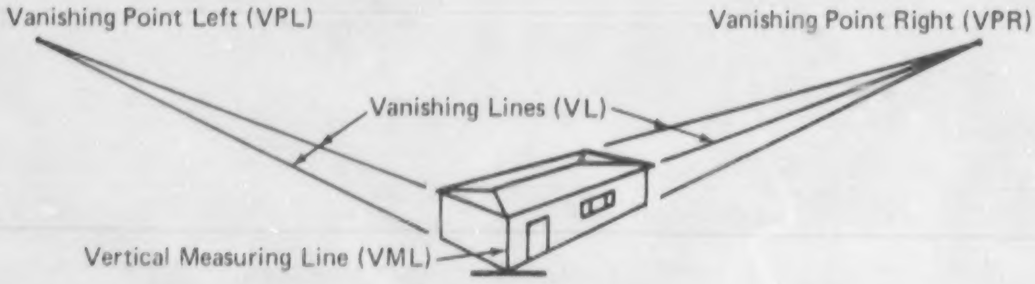
Plan View


Picture Plane
Height of Building
Recorded on Picture
Plane
Visual Ray Lines
SP
Horizon Line (HL)
Ground Line (GL)

Elevation

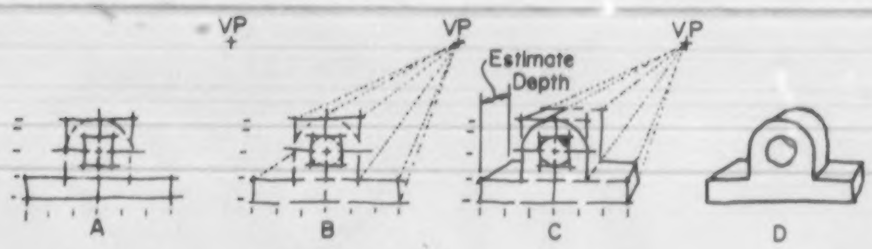

Length from Plan View
Picture Plane
Height from Elevation View

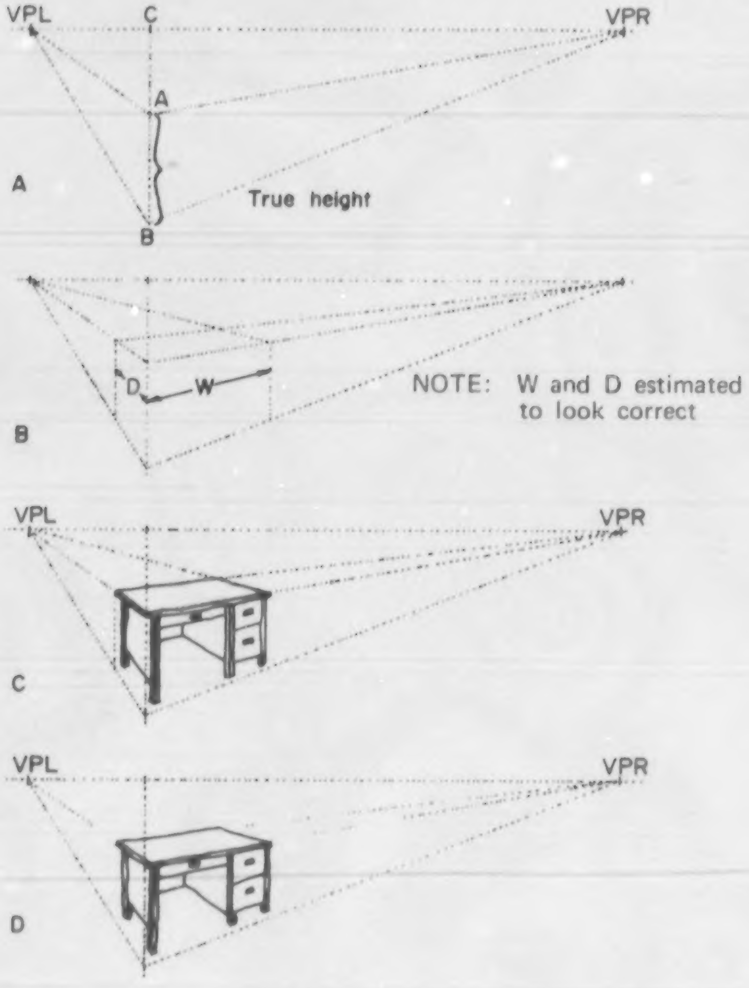
Picture Recorded on Picture Plane as Seen by Viewer


Vanishing Point Left (VPL)
Vanishing Point Right (VPR)
Vanishing Lines (VL)
Vertical Measuring Line (VML)

Perspective

One Point and Two Point Perspective Sketching


VP
VP
Estimate Depth
VP
A
B
C
D


VPL
C
VPR
A
A
True height
B
B
D
W
NOTE: W and D estimated to look correct
VPL
VPR
C
VPL
VPR
D

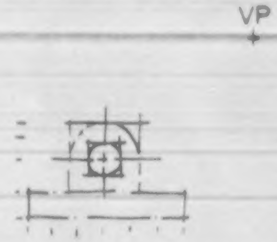
PERSPECTIVE
UNIT XI

ASSIGNMENT SHEET #1--SKETCH A ONE POINT PERSPECTIVE

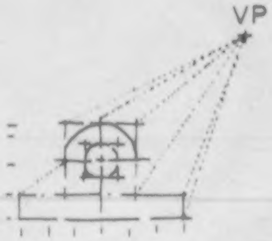
Premise: A one point perspective can be sketched by using the procedure in the following example. Refer to Transparency 6 if needed.

Example:

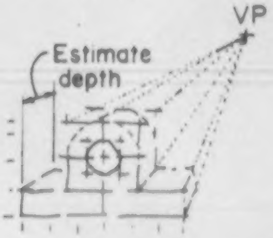
1. Take the object, block in a front view, and select a vanishing point



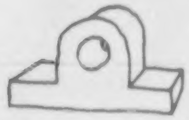
2. Sketch all the receding lines to the vanishing point



3. Estimate the depth of the object and sketch in the back portion of the object

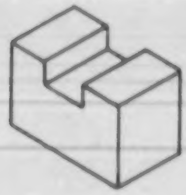


4. Use an artgum eraser to dim construction lines and darken in visible lines



ASSIGNMENT SHEET #1

Directions: Make a one point perspective of the following object.



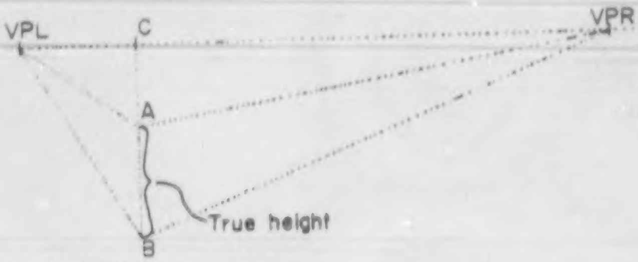
PERSPECTIVE
UNIT XI

ASSIGNMENT SHEET #2--SKETCH A TWO POINT PERSPECTIVE

Premise: A two point perspective can be sketched by using the procedure in the following example. Refer to Transparency 6 if needed.

Example:

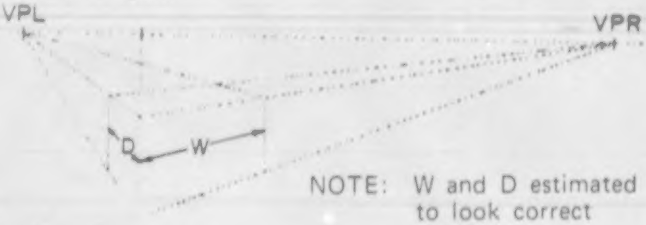
1. Sketch the front corner of the object in the true height



2. Locate the VPL and VPR on the horizon line

   (NOTE: The distance to the horizon line may vary.)

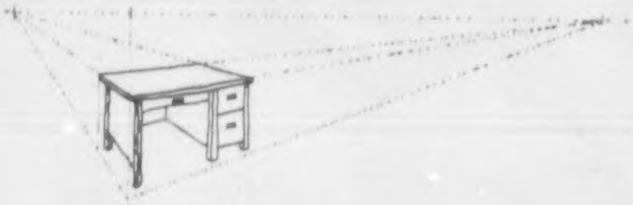
3. Estimate the depth and width of the object



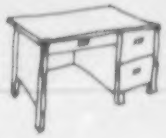
NOTE: W and D estimated to look correct

4. Block in all detail of remaining items

   (NOTE: Most lines will go to either the VPL or VPR.)

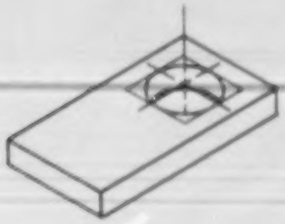


5. Use an artgum eraser to dim construction lines and darken in visible line



ASSIGNMENT SHEET #2

Directions: Make a two point perspective of the following object.



PERSPECTIVE
UNIT XI

ASSIGNMENT SHEET #3--CONSTRUCT A ONE POINT PERSPECTIVE

Premise: A one point perspective can be constructed by using the procedure in the following example. A one point perspective illustration is included with this assignment sheet for visual guidelines.

Example:

1. Construct the picture plane near the top of the vellum

   (NOTE: Provide space for the plan view.)

2. Construct one plane of the object on the picture plane so it will be drawn in its true size and shape; then complete plan view
3. Locate the station point far below to the left or right of the plan view

   (NOTE: The visual ray lines that will enclose the object on an angle should not be greater than 30°.)

4. Construct the horizon line near the station point
5. Construct the ground line below the horizon line

   (NOTE: Provide enough distance between ground line and horizon line for elevation view.)

6. Construct the bottom of the elevation view on the ground line at the left or right side of vellum
7. Project a line from station point above to intersect horizon line

   (NOTE: This will provide the vanishing point.)

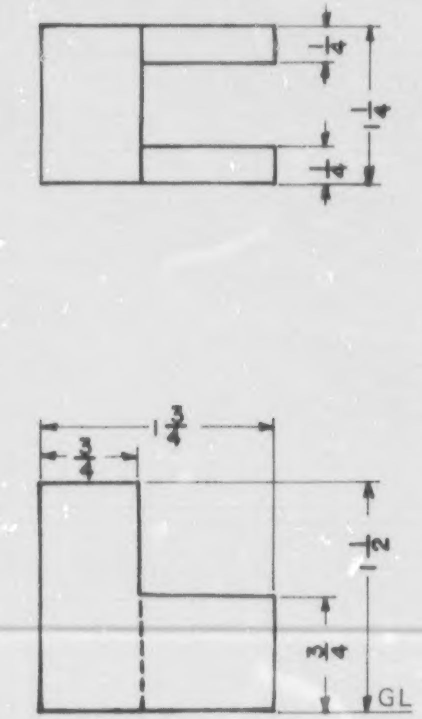
8. Construct lines from station to the corners of the plan view
9. Construct vertical lines downward where these lines intersect the picture plane
10. Project horizontal lines from the elevation view to intersect the vertical lines from plan view
11. Connect all points of intersection

    (NOTE: Corners and the required shape of the one point perspective will now be formed.)

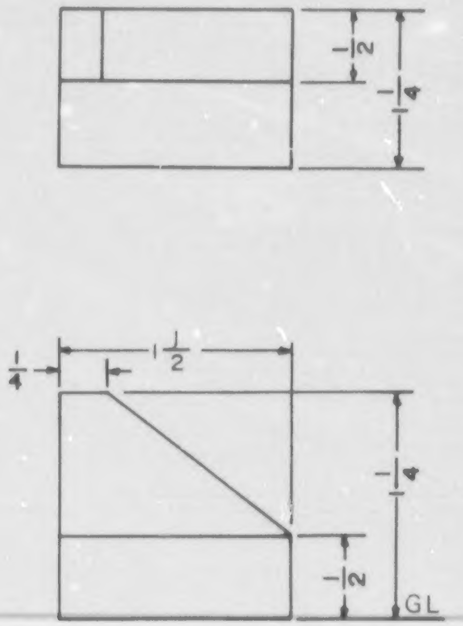
ASSIGNMENT SHEET #3

Directions: Construct a one point perspective on media recommended by instructor with standard borders and title block for the following problems.

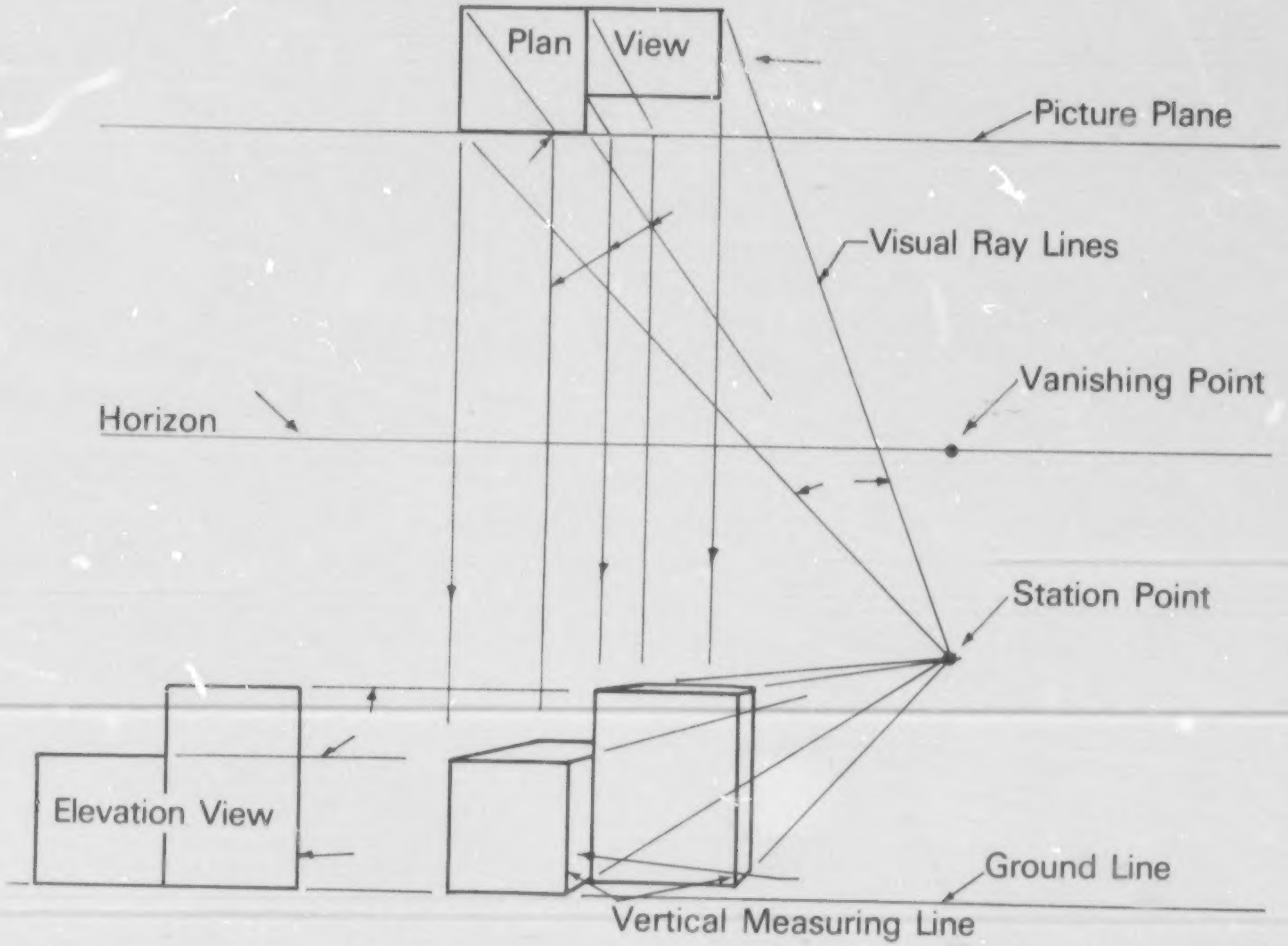
Problem A:


1/4
1 1/4
1/4
1 3/4
3/4
1 1/2
3/4
GL

Problem B:


1/2
1 1/4
1/4
1 1/2
1 1/4
1/2
GL

One Point Perspective


Plan View
Picture Plane
Visual Ray Lines
Vanishing Point
Horizon
Station Point
Elevation View
Ground Line
Vertical Measuring Line

ASSIGNMENT SHEET #3

PERSPECTIVE
UNIT XI

ASSIGNMENT SHEET #4--CONSTRUCT A TWO POINT PERSPECTIVE

Premise: A two point perspective can be constructed by using the procedure in the following example. Refer to Transparency 4 if needed.

Example:

1. Construct the picture plane near the top of the vellum

   (NOTE: Provide space for the plan view.)

2. Construct the plan view of the object so that the corner touches the picture plane

   (NOTE: Rotation should not be more than 30°.)

3. Locate the station point below and far enough in front of the picture plane

   (NOTE: A short distance will give a distorted view. It should be above the elevation view.)

4. Construct the horizon line near the station point

5. Construct the ground line below the horizon line

   (NOTE: Provide enough distance between ground line and horizon line for elevation view.)

6. Construct the bottom of the elevation view on the ground line

7. Construct parallel lines parallel to edges of plan view from station point to intersect picture plane

   (NOTE: The included angle between these lines is 90°.)

8. Construct perpendicular lines from picture plane intersection to horizontal line

   (NOTE: This will locate the two vanishing points for the perspective.)

9. Construct lines from corners of the object to station point piercing with picture plane

10. Construct horizontal lines from corners of elevation view to vertical measuring line; from these intersections construct lines to vanishing points

    (NOTE: These lines are the heights of the perspective.)

ASSIGNMENT SHEET #4

11. Construct vertical lines from picture plane to intersect vanishing lines

    (NOTE: This represents the perspective box of the object.)

12. Proceed in the following order to cut out the box or find a point in the object:

    a. Construct heights of the object in the perspective and then project to vanishing points to form edges of a plan in the box

    b. Construct a line from a point or cut to near edges of the plan view; then project picture plane to the lines just drawn on the perspective, and then to the vanishing points

    (NOTE: Their intersection is the end of cut or point.)

13. Proceed in the following order to find any true height not in the picture plane:

    a. Construct a line from a point not on the picture plane parallel to plan view lines to the picture plane

    b. Project this line to the ground line

    c. Project the height of the point from elevation view to intersect this line; from these intersections project to vanishing point

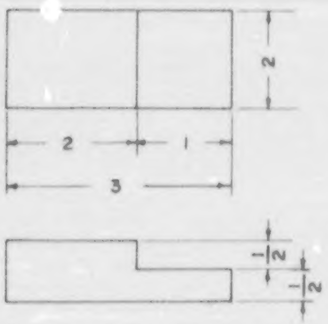
    (NOTE: This is the true height of the point in the perspective.)

14. Connect all points of intersection

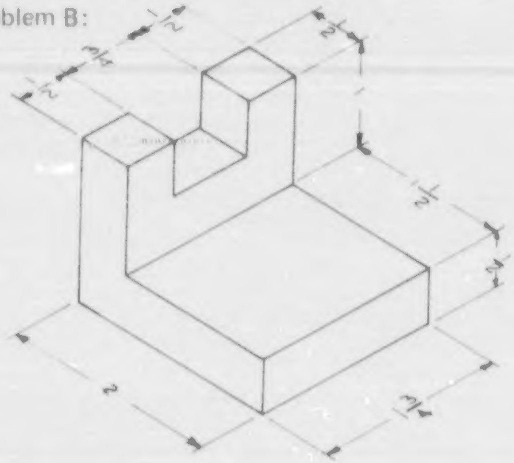
    (NOTE: The corners and required shape of the two point perspective will then be formed.)

Directions: Construct two point perspectives for the following problems.

Problem A:

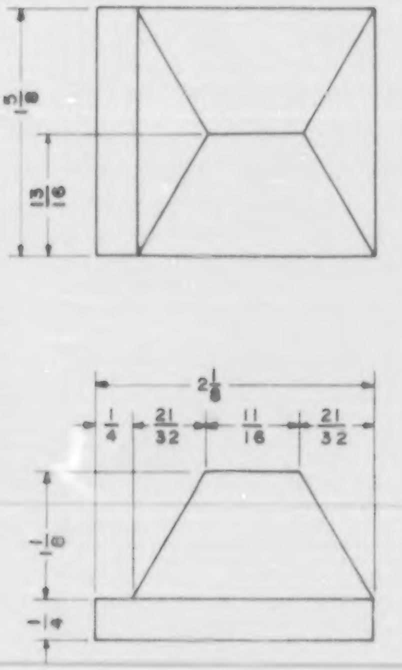


Problem B:



ASSIGNMENT SHEET #4

Problem C:


1 5/8
13/16
2 1/8
1/4
21/32
11/16
21/32
1 1/8
1/4

PERSPECTIVE
UNIT XI

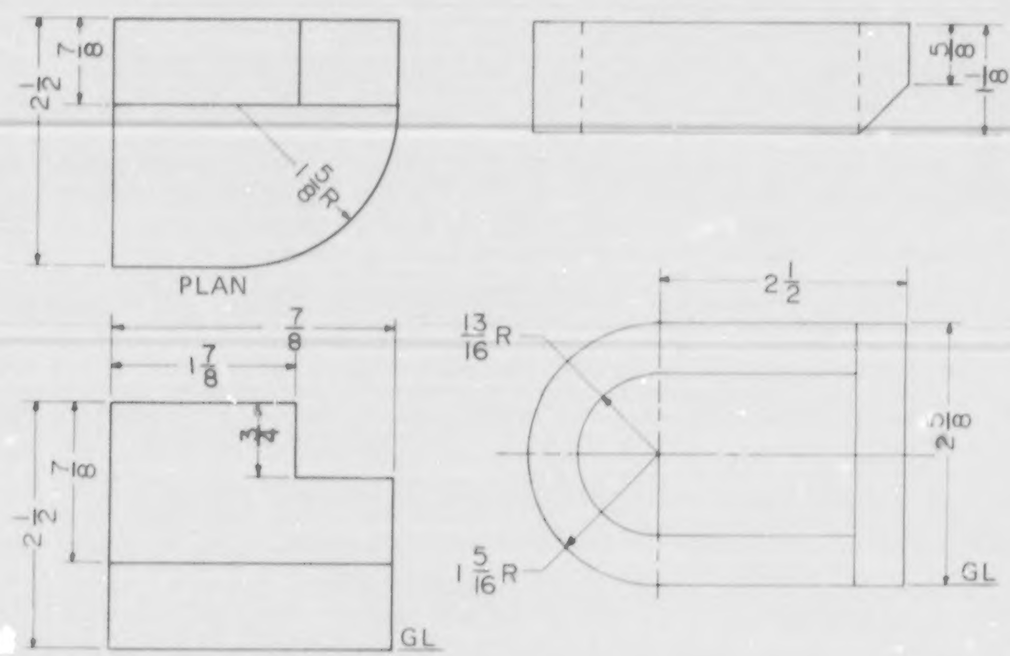
ASSIGNMENT SHEET #5–CONSTRUCT CURVES IN A PERSPECTIVE

Premise: Curves can be constructed in a perspective by using the procedure in the following example. An illustration is included on the next page for visual guidelines.

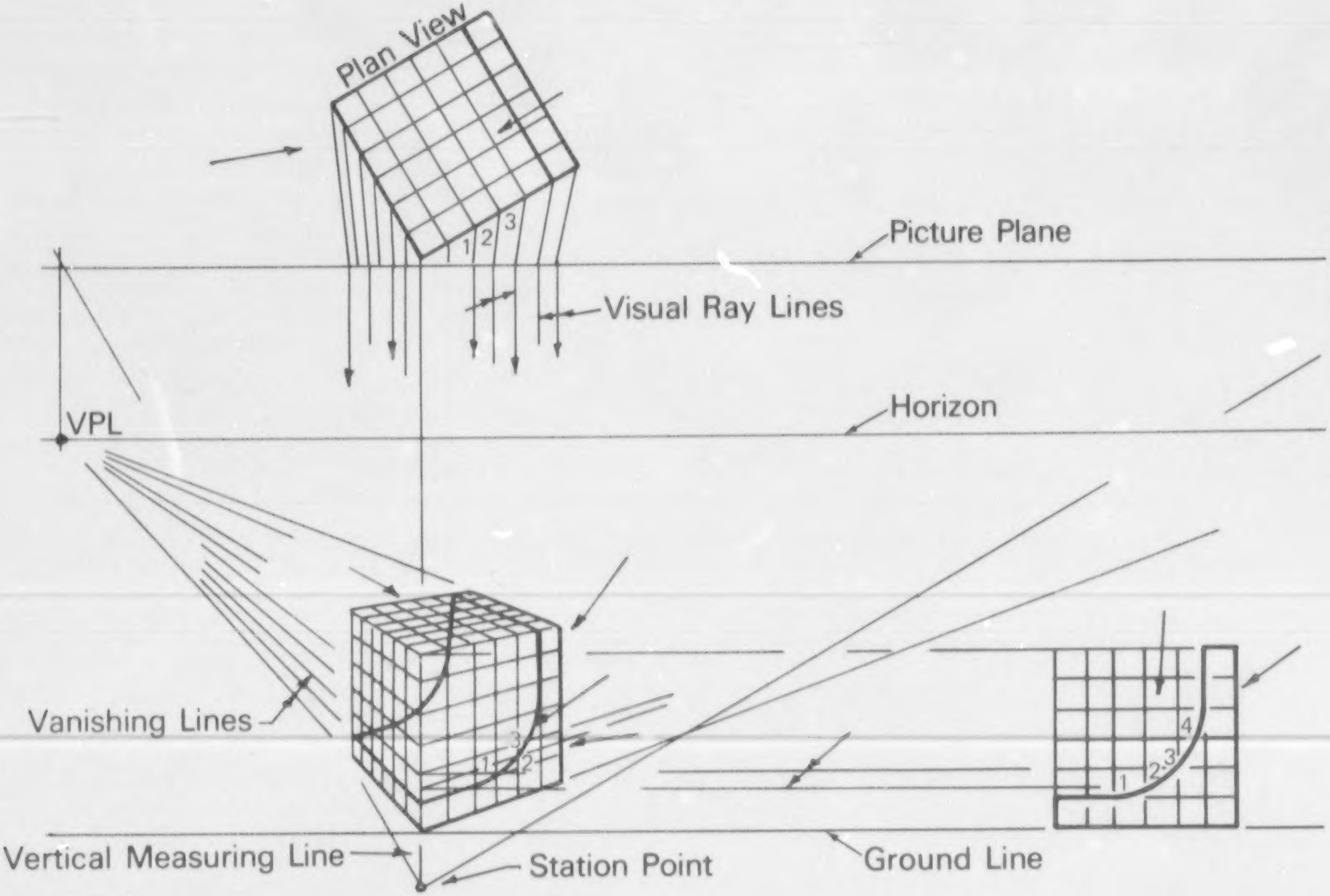
Example:

1. Refer to Assignment Sheet #2 for directions for construction of a perspective of an object
2. Construct a square grid on the elevation and plan views
3. Construct this grid in perspective
4. Project horizontal lines to intersect in perspective from common points in plan and elevation views
5. Connect the intersecting of lines in perspective with irregular curve or template to form curve

Directions: Construct curves in a perspective for the following problem.



Curves in a Perspective


Plan View
1
2
3
Picture Plane
Visual Ray Lines
Horizon
VPL
Vanishing Lines
3
1
2
4
2
3
1
Vertical Measuring Line
Station Point
Ground Line

ASSIGNMENT SHEET #5

PERSPECTIVE
UNIT XI

NAME ______________________________

TEST

1. Match the terms on the right with their correct definitions.

_____ a. Eye level of the person viewing the drawing and the line on which the vanishing points are located

_____ b. Bottom of the object being drawn

_____ c. Has only one vanishing point and the frontal plane of the object is parallel to the picture plane

_____ d. Projection plane of the plan view of the object being drawn

_____ e. Assumed plan view point representing the observer's eye

_____ f. Has two vanishing points

_____ g. Lines of the object which meet on the vanishing points

_____ h. Pictorial drawing made by the intersection of the picture plane with lines of sight meeting from points on the object to the point of sight

_____ i. Lines of sight from selected points on the object which pierce the picture plane on their way to the station point

_____ j. Has three vanishing points

_____ k. Part of the object closest to the person viewing the object on which true heights are measured

_____ l. Graph oriented method for making accurate perspectives without having to establish vanishing points and measure lines

_____ m. Has variety of scales and permits direct reading for layout of perspectives

_____ n. Process of drawing pictures for display as opposed to making detailed working drawings

_____ o. A point on the horizon at which receding parallel lines seem to meet

1. Vanishing lines
2. Picture plane
3. Three point perspective
4. Ground line
5. Delineation
6. Station point
7. Visual ray lines
8. Horizon line
9. Vanishing point
10. One point perspective
11. Perspective grid
12. Two point perspective
13. Perspective board
14. Vertical measuring line
15. Perspective

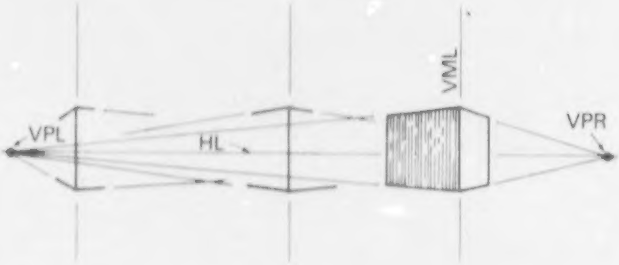
2. List three types of perspectives.

a. ____________________

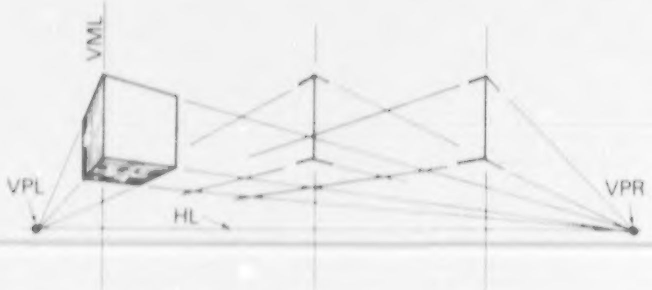
b. ____________________

c. ____________________

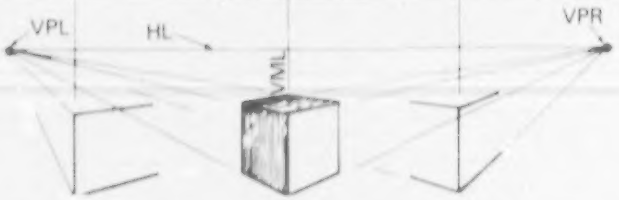
3. Identify the types of perspective views.


VML
VPL
HL
VPR

a. ____________________


VML
VPL
HL
VPR

b. ____________________


VPL
HL
VPR
VML

c. ____________________

4. List three types of perspective equipment.

a. ____________________

b. ____________________

c. ____________________

5. List the use of each type of perspective.

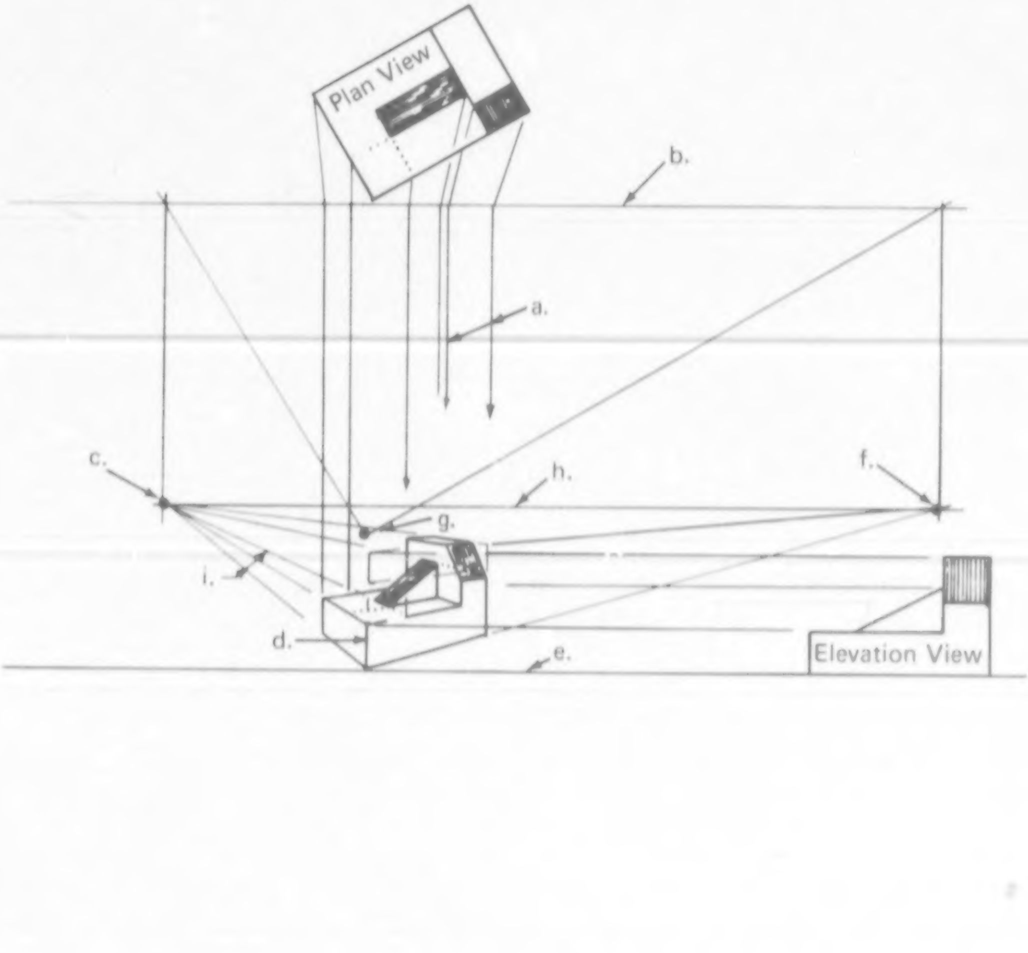
   a. One point--

   b. Two point--

   c. Three point--

6. Identify the lines and points in a two point perspective.

a.	______________________	f.	______________________
b.	______________________	g.	______________________
c.	______________________	h.	______________________
d.	______________________	i.	______________________


Plan View
b.
a.
c.
h.
f.
g.
i.
d.
e.
Elevation View

7. Select true statements concerning the steps in sketching a one point perspective by placing an "X" in the appropriate blanks.

______a. Take the object, block in a top view, and select a vanishing point

______b. Sketch all receding lines to the vanishing point

______c. Estimate the width of the object and sketch in the front portion of the object

______d. Use an artgum eraser to dim visible lines and darken in construction lines

8. Select true statements concerning the steps in sketching a two point perspective by placing an "X" in the appropriate blanks.

______a. Sketch the front corner of the object in the true height

______b. Locate the VPL and VPR on the picture plane

______c. Estimate the depth and width of the object

______d. Block in all detail of remaining items

______e. Use an artgum eraser to dim visible lines and darken in construction lines

9. Match terms on the right with their correct letter designations.

______a. PP

______b. HL

______c. VPL

______d. VL

______e. VPR

______f. SP

______g. VML

______h. VRL

______i. GL

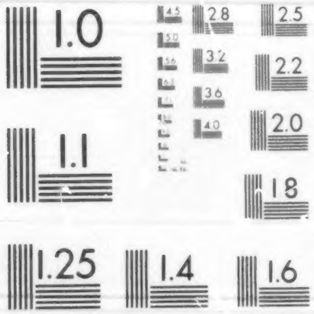
______j. VP

1. Horizon line
2. Ground line
3. Vanishing point left
4. Station point
5. Visual ray lines
6. Picture plane
7. Vanishing lines
8. Vertical measuring line
9. Vanishing point right
10. Vanishing points

10. Demonstrate the ability to:
    - a. Sketch a one point perspective.
    - b. Sketch a two point perspective.
    - c. Construct a one point perspective.
    - d. Construct a two point perspective.
    - e. Construct curves in a perspective.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

1


1.0
4.5
5.0
5.6
6.3
7.1
8.0
9.0
10.0
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

PERSPECTIVE
UNIT XI

ANSWERS TO TEST

1. a. 8
   b. 4
   c. 10
   d. 2
   e. 6
   f. 12
   g. 1
   h. 15
   i. 7
   j. 3
   k. 14
   l. 11
   m. 13
   n. 5
   o. 9

2. a. One point
   b. Two point
   c. Three point

3. a. Horizon
   b. Above horizon
   c. Below horizon

4. a. Grids
   b. Board
   c. Machine

5. a. Represents the interior of an object
   b. Represents the exterior of an object
   c. Represents the exterior of an object

6. a. Visual ray lines
   b. Picture plane
   c. Vanishing point left
   d. Vertical measuring line
   e. Ground line
   f. Vanishing point right
   g. Station point
   h. Horizon line
   i. Vanishing lines

7. b

8. a,c,d

9. a. 6
   b. 1
   c. 3
   d. 7
   e. 9
   f. 4
   g. 8
   h. 5
   i. 2
   j. 10

10. Evaluated to the satisfaction of the instructor

COMPUTER-AIDED DRAFTING
UNIT XII

UNIT OBJECTIVE

After completion of this unit, the student should be able to operate a computer-aided drafting system, store and retrieve programs from tape, operate a digitizer, and construct multi-view drawings on the plotter using BASIC. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match CAD equipment terms with their correct definitions.
2. Match CAD terminology with their correct definitions.
3. List hardware used in a CAD system.
4. Distinguish between input and output devices in a CAD system.
5. Match BASIC operator symbols or words with the correct descriptions.
6. Match BASIC statement words used for programs on tape with the correct functions.
7. Match BASIC statement words used in graphics with the correct functions.
8. Select true statements concerning operating a Tektronix CAD system.
9. Demonstrate the ability to:
    a. Program in BASIC using a micro-computer as a calculator.
    b. Create drawings on a micro-computer using plot method.
    c. Construct a two-view drawing using straight line statements.
    d Construct a two-view drawing using straight line, circle, and hidden line statements.
    e. Start up and shut down the available CAD system.
    f. Load from and store onto tape a program.
    g. Operate a digitizer tablet.

COMPUTER-AIDED DRAFTING
UNIT XII

SUGGESTED ACTIVITIES

I. Provide student with objective sheet.

II. Provide student with information, assignment, and job sheets.

III. Make transparencies.

IV. Discuss unit and specific objectives.

V. Discuss information and assignment sheets.

VI. Demonstrate and discuss the procedures outlined in the job sheets.

VII. Take students on a field trip to visit an industry that has a CAD or IGS system.

VIII. Survey class to determine how many students have previous typing experience. This is very helpful when working with computers and CAD systems.

IX. Demonstrate keyboard operations and BASIC on Radio Shack TRS-80, Apple computer, or similar micro-computers if equipment is available.

X. Have students perform activities on job sheets before assignment sheets are started.

XI. Give test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objective sheet

B. Information sheet

C. Transparency masters

1. TM 1--Computer-Aided Drafting System --Micro-Computer
2. TM 2--Computer-Aided Drafting System --Large Computer
3. TM 3--BASIC Statement Parts
4. TM 4--Graphic Computing System
5. TM 5--Digital Plotter
6. TM 6--Digitizer Tablet

D. Assignment sheets

1. Assignment Sheet #1--Program in BASIC Using a Micro-Computer As a Calculator

2. Assignment Sheet #2--Create Drawings On a Micro-Computer Using Plot Method

3. Assignment Sheet #3--Construct a Two-View Drawing Using Straight Line Statements

4. Assignment Sheet #4--Construct a Two-View Drawing Using Straight Line, Circle, and Hidden Line Statements

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Start Up and Shut Down the Available CAD System

2. Job Sheet #2--Load From and Store Onto Tape a Program

3. Job Sheet #3--Operate a Digitizer Tablet

G. Test

H. Answers to test

II. References:

A. Brown, Walter C. *Drafting for Industry*. South Holland, Illinois 60473: Goodheart-Willcox Co., Inc., 1974.

B. Demel, John T., and Robert A. Wilke. *Computer Graphics*. College Station, TX 77840: Creative Publishing Co., 1976.

C. *Level II BASIC Reference Manual*. Fort Worth, TX 76102: Radio Shack, 1979.

D. *Plot 50 Introduction to Programming in BASIC*. Beaverton, OR 97077: Tektronix, Inc., 1978

E. Sutherlin, Tom. *Computer Aided Design and Drafting*. Mimeographed. Lawton, OK, 1980.

F. Giloi, Wolfgang K. *Interactive Computer Graphics*. Englewood Cliffs, New Jersey 07632: Prentice-Hall, Inc., 1978.

G. Peckham, Herbert D. *Programming BASIC With the TI Home Computer*. St. Louis: McGraw-Hill Book Co., and Texas Instruments, Inc., 1979.

H. Van Hoy, Andy. *Interactive Graphic Systems Software Program*. Mimeographed. Lawton, OK, 1980.

COMPUTER-AIDED DRAFTING
UNIT XII

INFORMATION SHEET

I. CAD equipment terms and definitions

A. Computer-aided drafting (CAD)--Process system used in designing industrial products and the production of graphic drawings with the aid of the computer and its related input and output devices

(NOTE: This system is often called the Interactive Graphics System--IGS. In this unit the computer-aided system will be referred to as CAD.)

B. Cathode ray tube (CRT)--A TV like display that can be a storage tube, plasma display, or refresh tube display

C. Computer--An electronic information-handling machine capable of performing arithmetical calculations and making logical decisions under the control of programs

D. Central processing unit (CPU)--The part of a computer system containing the system's arithmetic, logic, primary storage, and controls of input and output peripheral devices

E. Peripheral devices--Various devices that are used in the CAD system in which data is input, stored, retrieved, and output from the CPU

(NOTE: These devices are external to the CPU.)

F. Micro-computer--Small, inexpensive computer that has a CPU and one or more input/output devices

G. Keyboard console--An input device, consisting of ASCII character keys, numeric keys, and math function keypad used by the computer operator before, during, and after running programs

H. Plotter--An X-Y type output device, usually drum or bed form, that produces line drawings on paper with a pen controlled by instructions from CPU or tape controller

I. Manual digitizer--An input device where digit or X-Y points are located by positioning the free-moving cursor or stylus on an electromagnetic grid embedded in the digitized board

J. Free-moving cursor--Contains a sensing coil connected to the digitizer control used for sighting a drawing coordinate X-Y points on the digitizer

K. Stylus--Used to locate coded programs of X-Y points by pressing at the point of drawing line intersect on digitizer board and input to CRT

L. Digitizer tablet--An input device using stored graphic symbols in the CPU where a designer uses a light pen, stylus, or free-moving cursor by positioning on tablet for each symbol to create a drawing on CRT

INFORMATION SHEET

M. Light pen--An input device used with a refreshed-picture display to create various edges, contours, or other features in a photographic image

N. Automated digitizer--Utilizes a television camera on an automated drafting machine to follow the line being digitized for output digits according to stored information in CPU

O. Line printer--An output device that prints one line of character information at a time from CPU

P. Hard copier--An output device that forms graphic and character images by electronic signals on paper from CPU

Q. Flexible disk--An oxide-coated plastic disk enclosed in a protective covering that can be used for storage of data

(NOTE: This is commonly called a floppy disk.)

R. Magnetic tape--Medium on which data is recorded in the form of magnetized spots on the surface of magnetically sensitive coated tape

S. Joy stick--Used as a graphic input and cursor positioning device to the CRT and CPU

II. CAD terminology and definitions

A. Program--Step-by-step instructions which cause the computer to solve a problem

B. Computer language--A set of mathematical commands such as add, divide, or multiply, or functional commands to "store in memory," "delete," or "draw"

C. Beginners All-purpose Symbolic Instruction Code (BASIC)--A symbolic English-like programming language

D. FORmula TRANslation (FORTRAN)--A high-level algebraic and logical language used in engineering and graphic systems

E. COmmon Business Oriented Language (COBOL)--A higher-level source programming language designed to process large files used by business

F. File--Collection of related data treated as a unit

G. Data--Facts of all kinds

H. Input--Data that is transferred to the CPU from an external peripheral device

I. Output--The results obtained from the CPU and transferred to a peripheral device

INFORMATION SHEET

J. American Standard Code for Information Interchange (ASCII)--Used as a standard code of alphanumeric characters, symbols, and special control characters

K. Graphics--Computer output that is composed of lines rather than letters, numbers, or symbols

L. Alphanumeric--The set of letters A-Z, the numerals 0-9, and various punctuation marks and special characters

M. Software--Prepared programs that simplify CPU operations that cause hardware to function

N. Hardware--Any physical equipment that is a part of the CAD system

O. Interface--The interconnecting methods or devices used in the CAD hardware system

Example: RS-232-C interface

P. K--Symbol denoting 1024 bytes of storage

Q. Machine language--A programming language that can be interfaced directly by the internal circuitry of the computer

R. Routine--A sequence of instructions to carry out a certain function

S. Statement--A complete instruction in machine language such as BASIC or FORTRAN

T. Variable--A quantity that can take on any of a given set of values

U. Cursor--Flashing rectangular dot or cross hair that indicates the current position on the screen

V. Read only memory (ROM)--That portion of the system memory that cannot be changed and may be read but not written

W. Random access memory (RAM)--Memory available to the user for writing programs and storing data

X. Digit--Any number from 0 through 9

Y. Bit--Binary digit; the smallest unit of information that can be recognized by a computer

(NOTE: This will always be a 0 or a 1.)

Z. Binary code--Two-digit numbering system composed of only 0 and 1

AA. Byte--Unit of computer memory, made up of a specified number of bits, which can represent any digit, letter of alphabet, or special character

BB. Chips--Miniaturized integrated circuits which compose ROM memory

INFORMATION SHEET

CC. Compiler--A computer program used to translate high-level source language programs into machine language programs

DD. Menu--Graphic symbols or information arranged in software to be retrieved at some later time

EE. Resolution--A measure of the number of separately addressable positions on the coordinate grid

Example: If a 10 inch display has 1023 addressable points along each X-Y axis, the resolution is 1023/10 or 102.3 points per inch

FF. Raster scan--A CRT scanning system where the electron beam moves horizontally across all X values first at each Y level, moving down each Y level until the screen is scanned

III. Hardware used in a CAD system (Transparencies 1 and 2)

A. CPU

B. CRT

C. Keyboard console

D. Plotter

E. Manual/Automated digitizer

F. Hard copier

G. Line printer

H. Free-moving cursor/stylus/light pen

I. Joy stick

J. Magnetic tape or flexible disk drives

IV. Input and output devices in a CAD system (Transparencies 1 and 2)

A. Input

1. CPU
2. Digitizers
3. Keyboard console
4. Plotter

(NOTE: A joy stick and an X-Y beam are used on some plotters.)

INFORMATION SHEET

  5. Light pen
  6. Card reader

B. Output

  1. Plotter
  2. Line printer
  3. Hard copier
  4. CRT
  5. Cursor/stylus/light pen
  6. Joy stick
  7. Magnetic tape or flexible disk drives
  8. CPU
  9. Magnetic drum

  (NOTE: Some devices are both input and output.)

V. BASIC operator symbols or words and descriptions (Transparency 3)

	SYMBOL/WORDS	DESCRIPTIONS
A.	(	Left parenthesis
B.	SIN, COS, TAN	Functions
C.	+ and - Monadic	Changing sign
D.	↑	Exponentiation
E.	*	Multiplication
F.	/	Division
G.	+	Addition
H.	-	Subtraction
I.	Min or Max	Comparative
J.	<	Less than
K.	>	Greater than
L.	>=	Greater than or equal to

INFORMATION SHEET

SYMBOL/WORDS	DESCRIPTIONS
M. <=	Less than or equal to
N. <>	Not equal to
O. =	Equal to

VI. BASIC statement words used for programs on tape and functions

STATEMENT WORDS	FUNCTIONS
A. Find	Positions tape at beginning of desired file
B. Mark	Creates on tape one or more files of desired length
C. Save	Causes the entire program currently in memory to be stored on tape
D. B Save	Stores memory on tape in binary code
E. Old	Retrieves program on tape back into memory
F. Bold	Retrieves program on tape in binary code back into memory (NOTE: CAD system must be equipped with binary loader ROMpack.)
G. T List	Determines on CRT screen how many files exist on tape
H. Append	Enables changing or add-on routines to programs on tape that are in memory

(NOTE: These statements and functions are for the Tektronix graphic system.)

VII. BASIC statement words used in graphics and functions (Transparency 3)

STATEMENT WORDS	FUNCTIONS
A. Draw	Produces a visible line between the last position of the cursor and the X-Y coordinates specified
B. R Draw	Produces a visible line to a location which is relative to its present position

INFORMATION SHEET

	STATEMENT	FUNCTION
C.	Move	Allows moving cursor on the screen without making a line with X-Y coordinates specified
D.	R Move	Allows moving the cursor to a location which is relative to its present position without making a line
E.	Rotate	Produces on angular displacement in the orientation of relative moves and draws
F.	Window	Allows selecting whatever portion of user data space you want to see on the screen
G.	View port	Allows using a desired portion of the screen in a window
H.	Scale	Ratio of user data units per graphics display unit (GDU)
I.	Axis	Draws a horizontal and vertical line through point of origin in the user data space

(NOTE: These statements and functions are for the Tektronix graphic system.)

VIII. Operating a Tektronix CAD system

A. Do not take the tape arrow off SAFE unless you intend to record on it

B. Do not type in FIND 1 on a new blank tape unless the tape has been rewound and MARK 1 entered

C. Do not operate computer when an electrical storm is in area because the memory may be erased

D. Memory will be erased if power is turned off while program is in memory

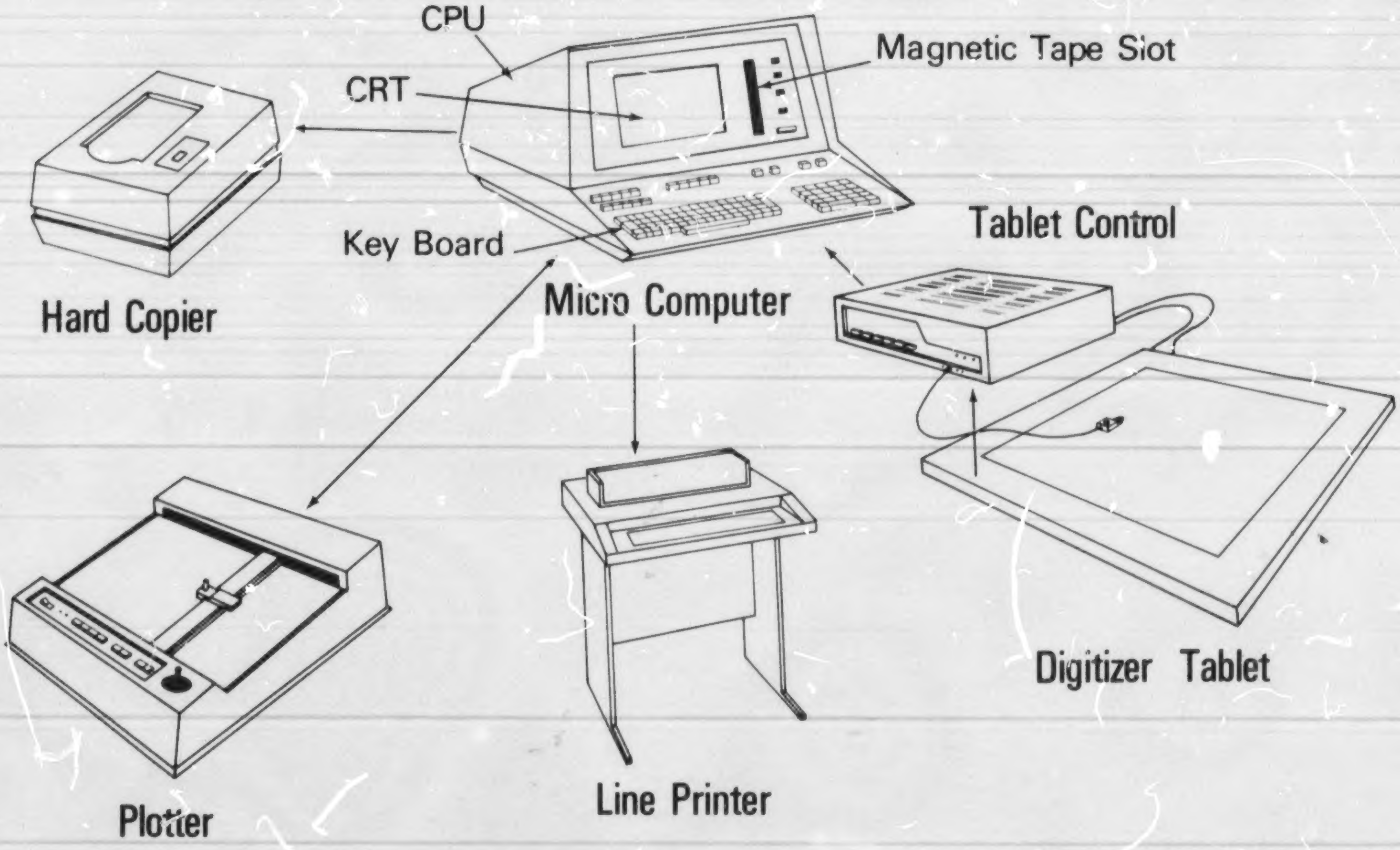
E. Do not grab pen while the plotter is running

F. Press LOAD key if you need to stop plotter

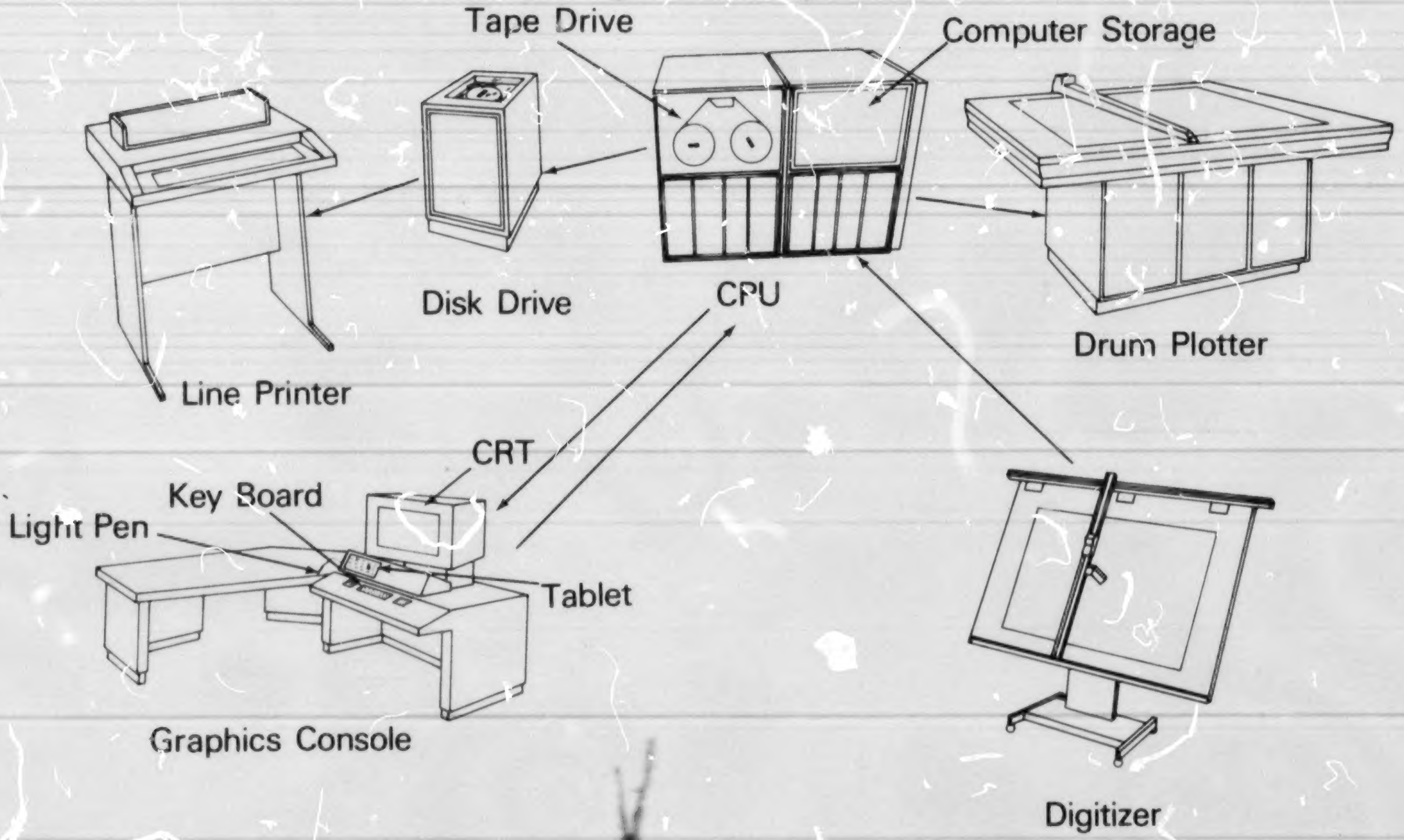
G. Keep cap on plotter pens when not in use

H. If screen is full and a flashing F is in upper left corner, press HOME/PAGE key

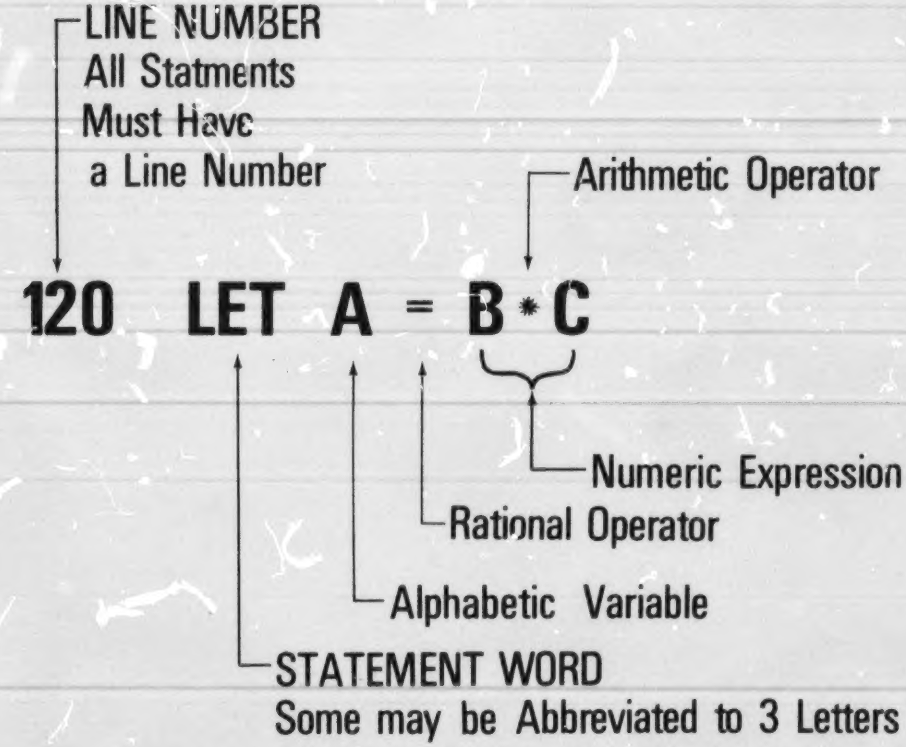
Computer-Aided Drafting System
Micro -Computer


CPU
CRT
Magnetic Tape Slot
Key Board
Micro Computer
Hard Copier
Tablet Control
Plotter
Line Printer
Digitizer Tablet

Computer-Aided Drafting System
Large Computer


Tape Drive
Computer Storage
Disk Drive
CPU
Drum Plotter
Line Printer
CRT
Key Board
Light Pen
Tablet
Graphics Console
Digitizer

Basic Statement Parts



LINE NUMBER
All Statments
Must Have
a Line Number

Arithmetic Operator

```
120 LET A = B * C
```

Numeric Expression

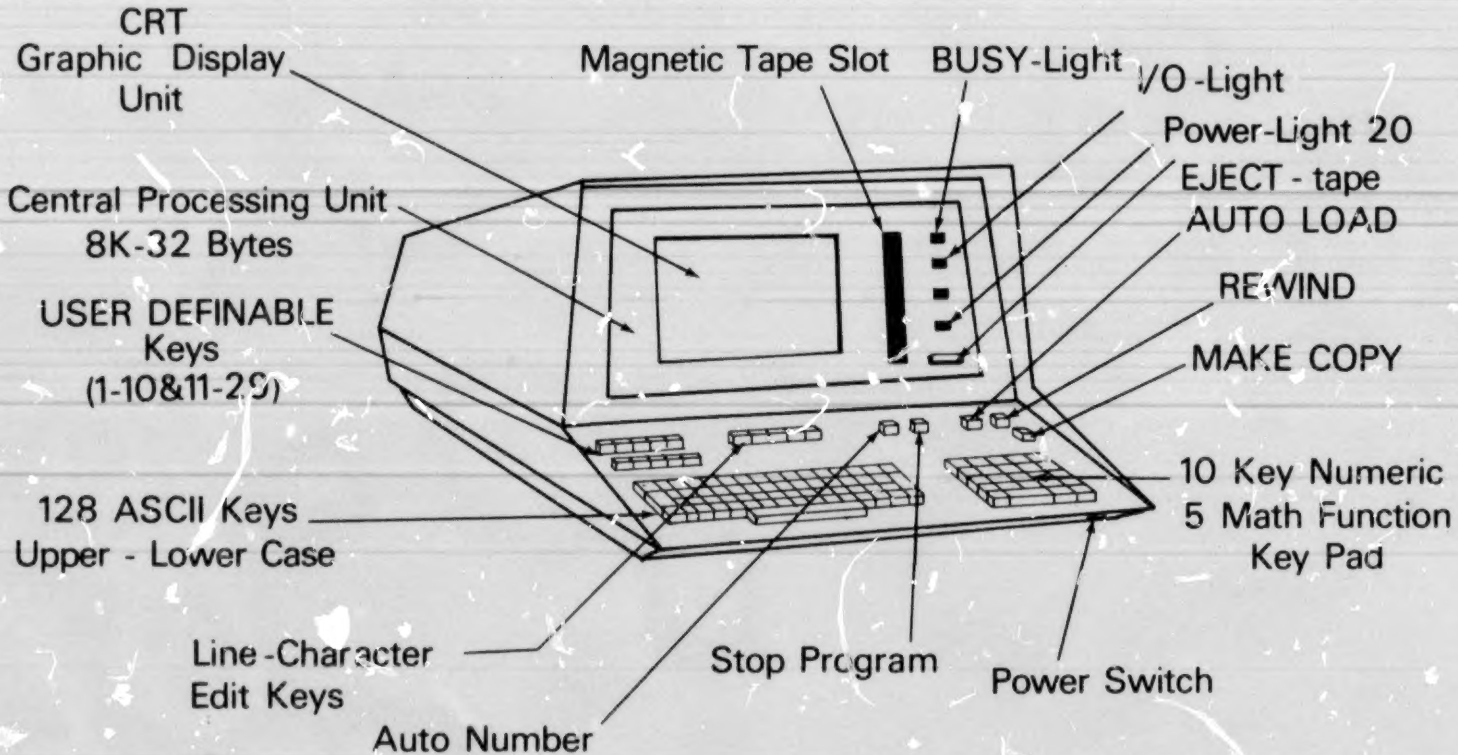
Rational Operator

Alphabetic Variable

STATEMENT WORD
Some may be Abbreviated to 3 Letters

Graphic Computing System

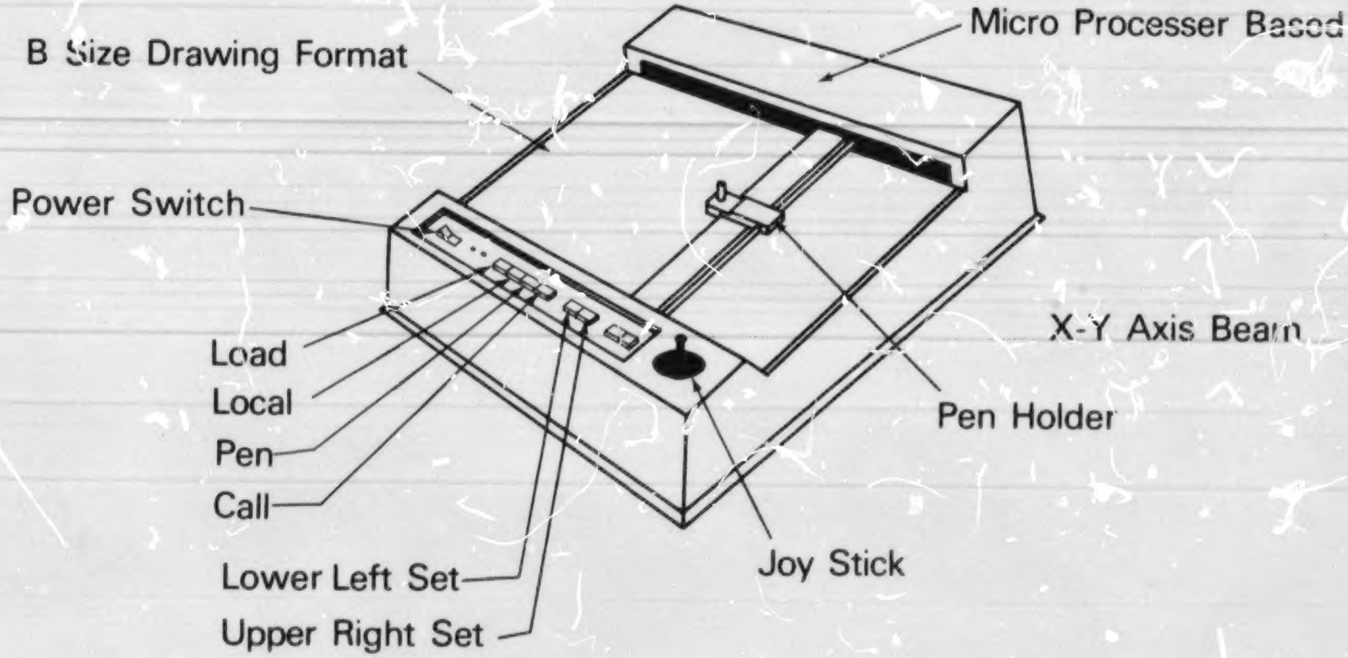
Tektronic 4051


CRT Graphic Display Unit
Magnetic Tape Slot
BUSY-Light
I/O -Light
Power-Light 20
EJECT - tape
AUTO LOAD
REWIND
MAKE COPY
Central Processing Unit 8K-32 Bytes
USER DEFINABLE Keys (1-10&11-20)
128 ASCII Keys Upper - Lower Case
10 Key Numeric 5 Math Function Key Pad
Line-Character Edit Keys
Stop Program
Power Switch
Auto Number

Note: Refer to User's Manual for Operating Procedures

Digital Plotter

Tektronic 4662

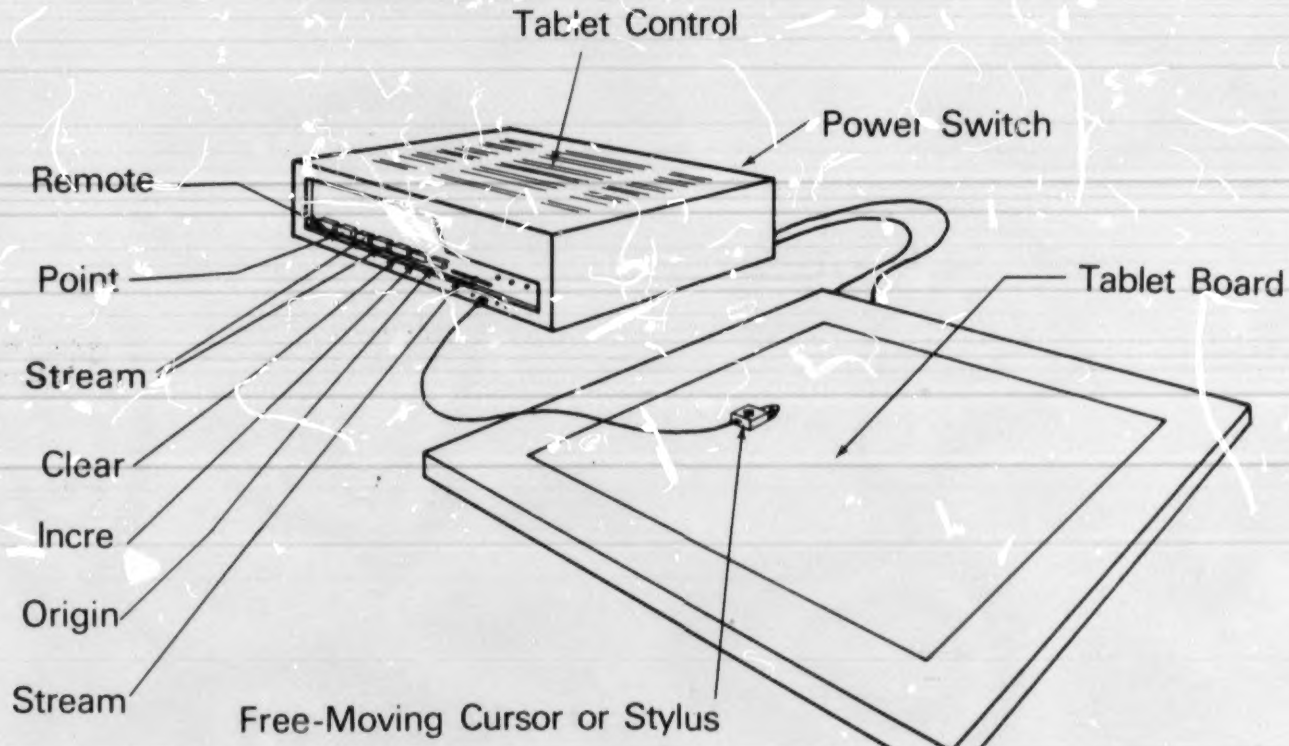

B Size Drawing Format
Micro Processer Based
Power Switch
X-Y Axis Beam
Pen Holder
Load
Local
Pen
Call
Joy Stick
Lower Left Set
Upper Right Set

Note: Refer to User's Manual for Connecting up System

TM 5

D II - 921

Digitizer Tablet


Tablet Control
Power Switch
Remote
Point
Stream
Clear
Incre
Origin
Stream
Tablet Board
Free-Moving Cursor or Stylus

Note: Refer to User's Manual for Connecting up System

COMPUTER-AIDED DRAFTING
UNIT XII

ASSIGNMENT SHEET #1--PROGRAM IN BASIC USING A MICRO-COMPUTER AS A CALCULATOR

Premise: Programming computer graphics problems must begin with the execution of discovery type activities found in micro-computer manufacturer's reference manuals. The following example and problems are activities in arithmetic operations using print and input statements.

Example:

1. Use the following chart and formulas for measurement of electricity in residential construction

W	Power	Watts
E	Voltage	Volts
I	Current	Ampere

Formulas: $W = E*I$ or $I = W/E$ or $E = W/I$

2. Turn computer on

(NOTE: Refer to manufacturer's manual for turning computer on, using special function keys, error messages, and editing statements.)

3. Type in the following program for calculating amperage

```
10 CLS                          Clears screen
20 REM                          To calculate amperage with current and
                                voltage given
                                Remarks statement
30 PRINT "ENTER TOTAL WATTAGE OF APPLIANCES IN WATTS."
40 INPUT W
50 PRINT "ENTER TOTAL VOLTAGE OF SYSTEMS IN VOLTS."
60 INPUT E
70 I = W/E
80 PRINT "THE AMPERAGE IS: ";I;" AMPS."
90 END
```

(NOTE: If you make mistakes while typing in the program, either retype the line or correct it by using the method outlined in the manufacturer's manual.)

4. Type in RUN

(NOTE: "ENTER TOTAL WATTAGE OF APPLIANCES IN WATTS." will now appear.)

5. Type in 1200 watts and press ENTER key

(NOTE: "ENTER TOTAL VOLTAGE OF SYSTEMS IN VOLTS." will now appear.)

ASSIGNMENT SHEET #1

6. Type in 120

   (NOTE: "THE AMPERAGE IS 10 AMPS" should now appear.)

7. Press the BREAK key and type in RUN

8. Now you are ready to add other voltage and wattage values for wattage calculations

Directions: Solve for unknown values in an electrical system by writing the programs and substituting the known values.

Problem A:	I	W	E
	______	1600	120
	______	800	120
	______	2400	120

Problem B:	W	E	I
	______	120	7
	______	120	3.5
	______	120	15

COMPUTER-AIDED DRAFTING
UNIT XII

ASSIGNMENT SHEET #2--CREATE DRAWINGS ON A MICRO-COMPUTER USING PLOT METHOD

Premise: No attempt is made to teach graphics programming in BASIC in this assignment sheet. There are many books on the market about graphics. Your instructor will help you in learning programming. The example given is for using the statement SET(X,Y) in creating lines and geometric shapes. This technique makes use of a numbered grid of 6144 tiny rectangles arranged in 48 rows of 128 columns.

Example:

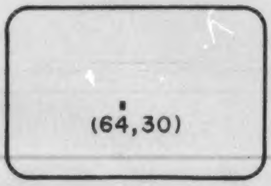
1. Turn the computer on
2. Type in the program listed below and press the ENTER key after each line

```
10 CLS                              Clears screen
20X = 64                            Column
```

(NOTE: Use manufacturer's video display worksheet.)

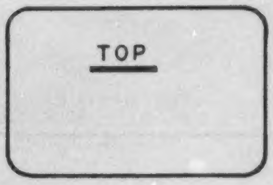
```
30Y = 30                            Row
40 SET(X,Y)                         Turns on point 64, 30

200 END
```



3. Type in RUN and press the ENTER key
4. Use the SET statement to draw a series of straight lines to create a square using the FOR-NEXT LOOP
5. Type in the program listed below for top line of square

```
10 CLS
20 Y = 20                           Y will always be 20 for this line
30 FORX = 54 TO 73                  FOR-NEXT  LOOPS will set each point from
                                      54, 20 through 73, 20
40 SET(X,Y)
50 NEXT X
60 GO TO 60
70 END
 RUN                                To see top line
```



(NOTE: If you make mistakes while typing in the program, either retype the line or correct it by using the method outlined in the manufacturer's manual.)

ASSIGNMENT SHEET #2

6. Clear the screen using CLS command and type in LIST

7. Continue with program listed below

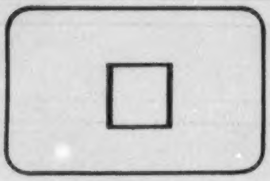
```
60 X = X  1                   Positions X on column 73
70 FOR Y = 20 TO 39
80 SET(X,Y)
90 NEXT Y                     Right side line
100 Y = Y  1                  Positions Y on row 39
110 FOR X = 72 TO 54 STEP  1  Makes line go backward
120 NEXT X                    X ends at 55 bottom line
130 X = X + 1: FOR Y = 38 TO 21 STEP  1: SET(X,Y): NEXT Y
 left  side
```

(NOTE: Multiple statement lines can be put on one line as shown in line 130 by adding colons.)

```
140 GO TO 140
150 END
```

8. Check and correct program for errors

9. Video display should look like the following figure after typing in RUN



(NOTE: It looks taller than wide because the lighted points are rectangles.)

Directions: Write and make a video display drawing of the problems given.

Problem A: A square with the sides of 15 point length and the starting point at 20, 10.

Problem B: A right triangle with left side and bottom side 10 points in length.

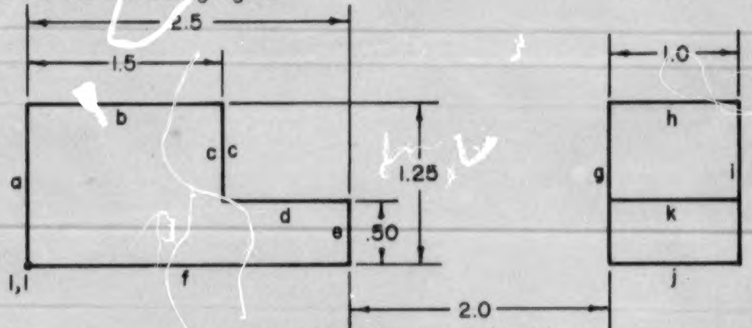
COMPUTER-AIDED DRAFTING
UNIT XII

ASSIGNMENT SHEET #3--CONSTRUCT A TWO-VIEW DRAWING USING STRAIGHT LINE STATEMENTS

Directions: Use the following procedure on a CAD system to construct a two-view drawing.

(NOTE: Refer to Job Sheet #1 if CAD system has not been started up.)

A. Type in the statements of the following figure



```
4 INIT                          4 is used for #1 user-definable key
5 Q = 32                        32 addresses CRT screen
6 GO TO 100
8 INIT                          8 is used for #2 user-definable key
9 Q=1                           1 addresses plotter
10 GO TO 100
100 PAGE                        clears screen
110 MOVE @ Q:0,0                sets origin in lower left corner
120 Scale 0.1,0.1               changes to inch measurement
125 REM John Doe                remark statement
130 MOVE @ Q:1,1                moves from origin xy distance to start line a
140 RDRAW @ Q:0,1.25            constructs line a
150 RDRAW @ Q:1.5,0             line b
160 RDRAW @ Q:0,-.75            line c
170 RDRAW @ Q:1,0               line d
180 RDRAW @ Q:0,-.50            line e
190 RDRAW @ Q:-2.5, 0           line f
200 RMOVE @ Q:4.5,0             moves to start line g
210 RDRAW @ Q:0,1.25            line g
220 RDRAW @ Q:1,0               line h
230 RDRAW @ Q:0,-1.25           line i
240 RDRAW @ Q:-1,0              line j
250 RMOVE @ Q:0,.5              moves to start line k
260 RDRAW @ Q:1,0               line k
270 END                         end of program
```

(NOTE: Check with instructor on statement syntax errors or refer to manufacturer's programming manual.)

ASSIGNMENT SHEET #3

B. Press USER DEFINABLE key 1

C. Check drawing on screen for errors

(NOTE: To check for program errors, press HOME/PAGE key and type in LIST.)

D. If drawing is correct, press USER DEFINABLE key 2

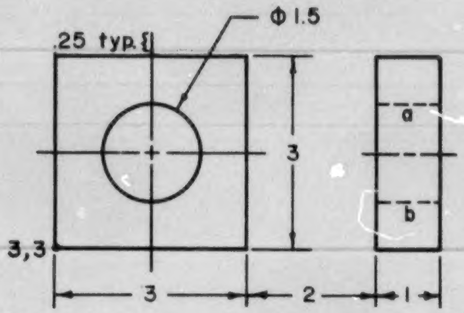
(NOTE: Remove pen cap if needed before pressing USER DEFINABLE key 2.)

COMPUTER-AIDED DRAFTING
UNIT XII

ASSIGNMENT SHEET #4--CONSTRUCT A TWO-VIEW DRAWING USING STRAIGHT LINE, CIRCLE, AND HIDDEN LINE STATEMENTS

Directions: Use the following procedure on a CAD system to construct a two-view drawing.

A. Type in the routine statements of the figure below and complete missing statements



```
4 INIT
5 Q=32
6 GO TO 110
8 INIT
9 Q=1
10 GO TO 110
110 PAGE
120 MOVE @ Q:0,0
130 SCALE 0.1,0.1
140 SET DEGREES                          For construction arcs and circles
150 REM JOHN DOE
160 MOVE @ Q:3,3
170 RDRAW @ Q:0,3
180 RDRAW @ Q:3,0
190 RDRAW @ Q:0,-3
200 RDRAW @ Q:-3,0
210 RMOVE @ Q:5,0
220 RDRAW @ Q:0,3
230 RDRAW @ Q:1,0
240 RDRAW @ Q:0,-3
250 RDRAW @ Q:-1,0
260 RMOVE @ Q-3.5,1.5                    Center of circle
270 REM Beginning of Circle
280 Let R = 0.75                         Radius of circle
290 GIN @ Q:A,B
300 RMOVE @ Q:R,0
310 For I = 10 to 360 STEP 10            Constructs 36 side polygon along
                                         path of circle
320 DRAW @ Q:R COS (I) * A, R SIN (I) * B
330 Next I
340 RMOVE @ Q:-2.50,0
350 REM Horiz Center Line
360 RDRAW @ Q:1.55,0
370 RMOVE @ Q:0.1,0
380 RDRAW @ Q:0.2,0
390 RMOVE @ Q:0.1,0
```

ASSIGNMENT SHEET #4

```
400 RDRAW @ 1.55,0
410 REM Vertical Center Line
420 RMOVE @ Q:-1.75,-1.75
430 RDRAW @ Q:0,1.55
440 RMOVE @ Q:0,0.1
450 RDRAW @ Q:0,0.2
460 RMOVE @ Q:0,0.1
470 RDRAW @ Q:0,1.55
480 RMOVE @ Q:3.25,-1.75
490 REM Right Horiz Center Line
500 ______________________________
510 ______________________________
520 ______________________________
530 ______________________________
540 ______________________________
550 REM Beginning of hidden line a
560 RMOVE @ Q:-1.25,-0.75
570 For I = 1 to 5 Step 1                    5 steps in 1 inch
580 RDRAW @ Q:0.1,0                          Dash 0.1 long
590 RMOVE @ Q:0.1,0 .........................Space 0.1 long
600 Next I
610 ______________________________
620 ______________________________
630 ______________________________
640 ______________________________
650 ______________________________
660 ______________________________
670 END
```

B. Press USER DEFINABLE key 1 to check drawing for errors on screen

C. If drawing is correct, press USER DEFINABLE key 2 for plotter to make drawing

COMPUTER-AIDED DRAFTING
UNIT XII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 13.333 amps

6.666 amps

20 amps

B. 840 watts

420 watts

1800 watts

Assignment Sheet #2

A.

```
10 CLS 20 Y = 10: FOR X = 20 TO 34: SET(X,Y): NEXT X
30X=X-1: FOR Y=11 TO 34: SET (X,Y): NEXT Y
40Y=Y-1: FOR X=33 TO 20 STEP 1: SET (X,Y): NEXT X
50X=X+1: FOR Y = 23 TO 11 STEP 1: SET (X,Y): NEXT Y
60 GO TO 60
70 END
```

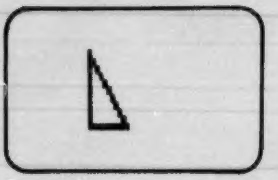
B.

```
100 CLS
110 X = 60
120 FOR Y = 18 TO 27
130 SET(X,Y)                 Draw the left side
140 NEXT Y
150 Y = 27
160 FOR X = 60 TO 69
170 SET(X,Y)                 Draw the bottom
180 NEXT X
190 X = 60: Y = 18
200 FOR N = 1 TO 10
210 SET(X,Y)                 Draw the hypotenuse
220 X = X + 1: Y = Y + 1
230 NEXT N
240 GO TO 240
250 END
```

ANSWERS TO ASSIGNMENT SHEETS

PLOTTED HYPOTENUSE VALUES

N	X	Y
1	60	18
2	61	19
3	62	20
4	63	21
5	64	22
6	65	23
7	66	24
8	67	25
9	68	26
10	69	27



Assignment Sheet #4

```
500 RDRAW @ Q:0.55,0
510 RMOVE @ Q:0.1,0
520 RDRAW @ Q:0.2,0
530 RMOVE @ Q:0.1,0
540 RDRAW @ Q:0.55,0

610 REM BEGINNING OF HIDDEN LINE b
620 RMOVE @ Q: -1, 1.5
630 FOR I = 1 to 5 Step 1
640 RDRAW @ Q: 0.1,0
650 RMOVE @ Q: 0.1, 0
660 Next I
```

COMPUTER-AIDED DRAFTING
UNIT XII

JOB SHEET #1--START UP AND SHUT DOWN THE AVAILABLE CAD SYSTEM

(NOTE: The job sheets in this unit are written using a Tektronix graphic system. If other equipment is used, the procedures will need to be changed.)

I. Tools and equipment

   A. Sheet of B size vellum

   B. Tektronix^R 4051 graphics computer

   C. Tektronix^R 4662 digital plotter

   D. 3M^R DC 300A 1/4" data cartridge tape or equal

II. Procedure (Transparencies 4, 5, and 6)

   A. Start up 4051 graphics computer

      1. Turn power on

      2. When screen is totally glowing, press HOME/PAGE key

   B. Start up 4662 plotter

      1. Check to see if interface cable is connected to plotter and graphics computer properly

      2. Turn power on

      3. Press down LOAD key

      4. Insert vellum and smooth out air bubbles under vellum

         (NOTE: Do not tape vellum to bed surface because plotter holds vellum to surface electrostatically.)

      5. Depress LOAD key

         (NOTE: To remove vellum, press LOAD key.)

      6. Use joy stick to move pen to lower left corner of desired drawing area and press LOWER LEFT SET until tone is heard

      7. Use joy stick to move pen to upper right corner of desired drawing area and press UPPER RIGHT SET until tone is heard

      8. Enter program in graphics computer

JOB SHEET #1

C. Shut down system

1. Turn power off digitizer tablet control
2. Turn power off plotter

   (NOTE: Cap must be on pens.)
3. Press HOME/PAGE key on graphics computer
4. Eject magnetic tape if in slot
5. Turn power off graphics computer

COMPUTER-AIDED DRAFTING
UNIT XII

JOB SHEET #2--LOAD FROM AND STORE ONTO TAPE A PROGRAM

I. Tools and equipment

   A. 1/4" magnetic data cartridge tape

   B. Tektronix^R 4051 graphics computer

II. Procedure

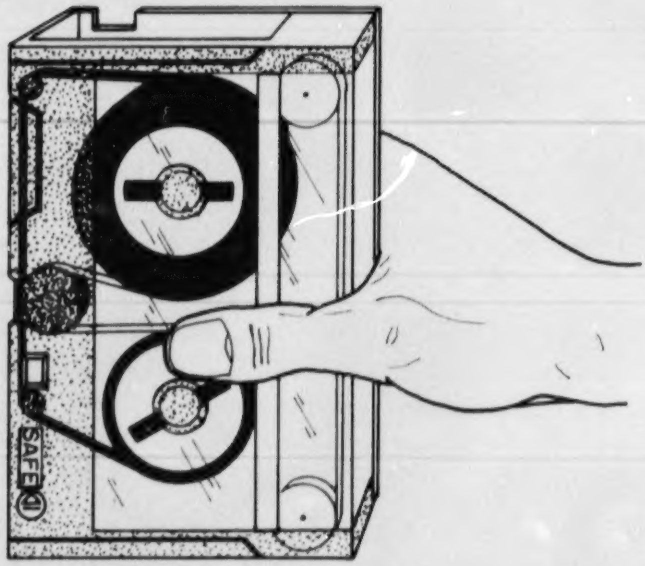
   A. Load from a tape a program into memory

      1. Turn power on graphics computer

         (NOTE: This is necessary if power has not been turned on.)

      2. Using your right hand, grasp the cartridge with your thumb on the plastic side and insert the tape into the magnetic tape slot

         (NOTE: Arrow should be turned to safe mark on plastic side at all times except for storing a program on tape.)



      3. Type in FIND 1, 2, or 3 etc. and wait until BUSY light is off

         (NOTE: File number where program is stored.)

JOB SHEET #2

4. Type in OLD and wait until BUSY light is off and flashing cursor appears in upper left corner of CRT screen

   (NOTE: This is to read program from tape into the memory.)

5. Type in RUN to execute the program in memory

B. Store onto tape a program in memory

1. Set the magnetic tape cartridge SAFE mark arrow to OFF position

2. Type in TLIST to show on CRT screen file numbers and new file number

3. Insert magnetic tape cartridge into tape slot

4. Type in FIND 1, 2, or 3 etc. and wait until BUSY light is off

5. Type in MARK 1, SPA and wait until BUSY light is off

   (NOTE: The tape will be marked one file length long enough to store the program space.)

6. Type in FIND 1, 2, or 3 etc. and wait until BUSY light is off

   (NOTE: This moves the tape back to beginning of new file number where program will be stored.)

7. Type in SAVE and wait until BUSY light is off

8. Eject tape cartridge and turn arrow to SAFE mark

C. Store onto new blank tape

1. Insert new magnetic tape cartridge into tape slot with SAFE mark arrow to OFF position

2. Press REWIND key

   (NOTE: Do not type in FIND 1 because there is not a file number and tape will unwind off reel.)

3. Type in MARK 1, SPA

4. Type in FIND 1

   (NOTE: Now you are ready to store a program on tape.)

COMPUTER-AIDED DRAFTING
UNIT XII

JOB SHEET #3--OPERATE A DIGITIZER TABLET

I. Tools and equipment

A. Tektronix^R 4051 graphics computer

B. Tektronix^R 4956 graphics tablet

C. Graphics tablet support software tape cartridge

II. Procedure

A. Check for proper connection of the tablet and graphics computer

(NOTE: Refer to user's manual for proper connections.)

B. Turn power on system

C. Insert tablet support software tape

D. Press AUTO LOAD key to display MENU

E. Select PEN DISPLAY ONLY program for this procedure

F. Type in number of program and press RETURN

G. Press POINT on tablet control

H. Set ORIGIN by press and hold ORIGIN button, then press pen on the tablet surface at the desired origin

I. Release ORIGIN button

J. Select display by typing in "g" for graphic display or "a" for coordinate display

K. Move pen to lower left corner of digitizing window and press once

L. Move pen to upper right corner of digitizing window and press once

M. To digitize, begin moving and pressing pen at desired locations

N. Program halts when USER DEFINABLE key 3 is pressed and the last point entered

O. To START program, type in RUN

P. Obtain MENU by pressing AUTO LOAD

COMPUTER-AIDED DRAFTING
UNIT XII

NAME ______________________

TEST

1. Match CAD equipment terms on the right with their correct definitions.

_____ a. Process system used in designing industrial products and the production of graphic drawings with the aid of the computer and its related input and output devices

_____ b. A TV like display that can be a storage tube, plasma display, or refresh tube display

_____ c. An electronic information-handling machine capable of performing arithmetical calculations and making logical decisions under the control of programs

_____ d. The part of a computer system containing the system's arithmetic, logic, primary storage, and controls of input and output peripheral devices

_____ e. Various devices that are used in the CAD system in which data is input, stored, retrieved, and output from the CPU

_____ f. Small, inexpensive computer that has a CPU and one or more input/output devices

_____ g. An input device, consisting of ASCII character keys, numeric keys, and math function keypad used by the computer operator before, during, and after running programs

_____ h. An X-Y type output device, usually drum or bed form, that produces line drawings on paper with a pen controlled by instructions from CPU or tape controller

_____ i. An input device where digit or X-Y points are located by positioning the free-moving cursor or stylus on an electromagnetic grid embedded in the digitized board

_____ j. Contains a sensing coil connected to the digitizer control used for sighting a drawing coordinate X-Y points on the digitizer

1. Keyboard console
2. Line printer
3. Computer
4. Free-moving cursor
5. Plotter
6. Flexible disk
7. Joy stick
8. Micro-computer
9. Cathode ray tube
10. Stylus
11. Hard copier
12. Magnetic tape
13. Light pen
14. Manual digitizer
15. Digitizer tablet
16. Computer-aided drafting
17. Peripheral devices
18. Central processing unit
19. Automated digitizer

______k. Used to locate coded programs of X-Y points by pressing at the point of drawing line intersect on digitizer board and input to CRT

______l. An input device using stored graphic symbols in the CPU where a designer uses a light pen, stylus, or free-moving cursor by positioning on tablet for each symbol to create a drawing on CRT

______m. An input device used with a refreshed-picture display to create various edges, contours, or other features in a photographic image

______n. Utilizes a television camera on an automated drafting machine to follow the line being digitized for output digits according to stored information in CPU

______o. An output device that prints one line of character information at a time from CPU

______p. An output device that forms graphic and character images by electronic signals on paper from CPU

______q. An oxide-coated plastic disk enclosed in a protective covering that can be used for storage of data

______r. Medium on which data is recorded in the form of magnetized spots on the surface of magnetically sensitive coated tape

______s. Used as a graphic input and cursor positioning device to the CRT and CPU

2. Match CAD terminology on the right with their correct definitions.

______a. Step-by-step instructions which cause the computer to solve a problem

______b. A set of mathematical commands such as add, divide, or multiply, or functional commands to "store in memory," "delete," "print out," or "draw"

______c. A symbolic English-like programming language

______d. A high-level algebraic and logical language used in engineering and graphic systems

______e. A higher-level source programming language designed to process large files used by business

1. Digit
2. Variable
3. Alphanumeric
4. Data
5. Program
6. Chips

_____f. Collection of related data treated as a unit

_____g. Facts of all kinds

_____h. Data that is transferred to the CPU from an external peripheral device

_____i. The results obtained from the CPU and transferred to a peripheral device

_____j. Used as a standard code of alphanumeric characters, symbols, and special control characters

_____k. Computer output that is composed of lines rather than letters, numbers, or symbols

_____l. The set of letters A-Z, the numerals 0-9, and various punctuation marks and special characters

_____m. Prepared programs that simplify CPU operations that cause hardware to function

_____n. Any physical equipment that is a part of the CAD system

_____o. The interconnecting methods or devices used in the CAD hardware system

_____p. Symbol denoting 1024 bytes of storage

_____q. A programming language that can be interfaced directly by the internal circuitry of the computer

_____r. A sequence of instructions to carry out a certain function

_____s. A complete instruction in machine language such as BASIC or FORTRAN

_____t. A quantity that can take on any of a given set of values

_____u. Flashing rectangular dot or cross hair that indicates the current position on the screen

_____v. That portion of the system memory that cannot be changed and may be read but not written

_____w. Memory available to the user for writing programs and storing data

7. K
8. Graphics
9. Hardware
10. Input
11. Software
12. Output
13. Computer language
14. Beginners All-purpose Symbolic Instruction Code
15. Resolution
16. Compiler
17. Bit
18. Interface
19. Raster scan
20. Random access memory
21. Read only memory
22. Statement
23. Byte
24. Routine
25. FORmula TRANslation
26. Binary code
27. Cursor
28. American Standard Code for Information Interchange
29. File
30. COmmon Business Oriented Language
31. Machine language
32. Menu

______x. Any number from 0 through 9

______y. Binary digit; the smallest unit of information that can be recognized by a computer

______z. Two-digit numbering system composed of only 0 and 1

______aa. Unit of computer memory, made up of a specified number of bits, which can represent any digit, letter of alphabet, or special character

______bb. Miniaturized integrated circuits which compose ROM memory

______cc. A computer program used to translate high-level source language programs into machine language programs

______dd. Graphic symbols or information arranged in software to be retrieved at some later time

______ee. A measure of the number of separately addressable positions on the coordinate grid

______ff. A CRT scanning system where the electron beam moves horizontally across all X values first at each Y level, moving down each Y level until the screen is scanned

3. List eight hardware used in a CAD system.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

4. Distinguish between input and output devices in a CAD system by placing an "X" next to the output devices.

______a. Hard copier

______b. Digitizer

______c. CRT

______d. Magnetic tape or flexible disk drives

______e. Keyboard console

______f. Card reader

5. Match BASIC operator symbols or words on the right with the correct descriptions.

______a. Left parenthesis

______b. Functions

______c. Changing sign

______d. Exponentiation

______e. Multiplication

______f. Division

______g. Addition

______h. Subtraction

______i. Comparative

______j. Less than

______k. Greater than

______l. Greater than or equal to

______m. Less than or equal to

______n. Not equal to

______o. Equal to

1. Min or Max
2. < >
3. /
4. ↑
5. *
6. (
7. -
8. < =
9. +
10. SIN, COS, TAN
11. =
12. > =
13. + and - Monadic
14. <
15. >

6. Match BASIC statement works used for programs on tape on the right with the correct functions.

______a. Positions tape at beginning of desired file

______b. Creates on tape one or more files of desired length

______c. Causes the entire program currently in memory to be stored on tape

______d. Stores memory on tape in binary code

______e. Retrieves program on tape back into memory

1. T List
2. Append
3. Mark
4. Save
5. B Save
6. Old
7. Find
8. Bold

______f. Retrieves program on tape in binary code back into memory

______g. Determines on CRT screen how many files exist on tape

______h. Enables changing or add-on routines to programs on tape that are in memory

7. Match BASIC statement words used in graphics on the right with the correct functions.

______a. Produces a visible line between the last position of the cursor and the X-Y coordinates specified

______b. Produces a visible line to a location which is relative to its present position

______c. Allows moving cursor on the screen without making a line with X-Y coordinates specified

______d. Allows moving the cursor to a location which is relative to its present position without making a line

______e. Produces on angular displacement in the orientation of relative moves and draws

______f. Allows selecting whatever portion of user data space you want to see on the screen

______g. Allows using a desired portion of the screen in a window

______h. Ratio of user data units per graphics display unit (GDU)

______i. Draws a horizontal and vertical line through point of origin in the user data space

1. R draw
2. Window
3. Axis
4. Rotate
5. Scale
6. Draw
7. View port
8. R move
9. Move

8. Select true statements concerning operating a Tektronix CAD system by placing an "X" in the appropriate blanks.

______a. Do not take the tape arrow off SAFE unless you intend to record on it

______b. Type in FIND 1 on a new blank tape before it has been rewound and MARK 1 entered

______c. Do not operate computer when an electrical storm is in area because the memory may be erased

______d. Memory will not be erased if power is turned off while program is in memory ______e. Do not grab pen while the plotter is running

______f. Press MARK key if you need to stop plotter

______g. Keep cap on plotter pens when not in use

______h. If screen is full and a flashing F is in upper left corner, press HOME/PAGE key

9. Demonstrate the ability to:

   a. Program in BASIC using a micro-computer as a calculator.

   b. Create drawings on a micro-computer using plot method.

   c. Construct a two-view drawing using straight line statements.

   d. Construct a two-view drawing using straight line, circle, and hidden line statements.

   e. Start up and shut down the available CAD system.

   f. Load from and store onto tape a program.

   g. Operate a digitizer tablet.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

COMPUTER-AIDED DRAFTING
UNIT XII

ANSWERS TO TEST

1.	a.	16	g.	1	m.	13	s.	7
	b.	9	h.	5	n.	19		
	c.	3	i.	14	o.	2		
	d.	18	j.	4	p.	11		
	e.	17	k.	10	q.	6		
	f.	8	l.	15	r.	12		

2.	a.	5	k.	8	u.	27
	b.	13	l.	3	v.	21
	c.	14	m.	11	w.	20
	d.	25	n.	9	x.	1
	e.	30	o.	18	y.	17
	f.	29	p.	7	z.	26
	g.	4	q.	31	aa.	23
	h.	10	r.	24	bb.	6
	i.	12	s.	22	cc.	16
	j.	28	t.	2	dd.	32
					ee.	15
					ff.	19

3. Any eight of the following:

   a. CPU
   b. CRT
   c. Keyboard console
   d. Plotter
   e. Manual/Automated digitizer
   f. Hard copier
   g. Line printer
   h. Free-moving cursor/stylus/light pen
   i. Joy stick
   j. Magnetic tape or flexible disk drives

4. a, c, d

5.	a.	6	f.	3	k.	15
	b.	10	g.	9	l.	12
	c.	13	h.	7	m.	8
	d.	4	i.	1	n.	2
	e.	5	j.	14	o.	11

6.	a.	7	e.	6
	b.	3	f.	8
	c.	4	g.	1
	d.	5	h.	2

7.	a.	6	d.	8	g.	7
	b.	1	e.	4	h.	5
	c.	9	f.	2	i.	3

ANSWERS TO TEST

8. a, c, e, g, h
9. Evaluated to the satisfaction of the instructor